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The impacts of policy alternatives and foreign demand fluctuations on the US rice market

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The impacts of policy alternatives and foreign demand fluctuations on the U.S. rice market

by

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1 INTRODUCTION

Government intervention in U.S. agriculture has had a long history over the last five decades. This continues to be a cornerstone of U.S. farm policy. The most important objectives of the farm commodity programs (Johnson, 1973) are the following:

1) Raise the average level of farm incomes to a more satisfactory level.

2) Achieve a reasonable degree of stability in farm prices and incomes.

3) Manage the supply of key farm products so that the first two objectives can be achieved without imposing unacceptably high costs upon taxpayers and consumers.

4) Improve the capability of U.S. agriculture to compete in international market while protecting it carefully but not completely from imports of competitive products.

5) Provide an adequate and stable supply of food and fiber for U.S. consumers at reasonable prices.

To achieve these objectives, nonrecourse loans, a deficiency (direct) payment scheme, and acreage controls are currently used. The mechanisms above are not the only federal policies influencing agriculture. Others involve taxes, credit, marketing orders, research and development, resource development, and extension. By some measures, agriculture receives more federal support relative to importance than any other sector of the economy (Congress of the United States, 1984). Specially, the U.S. rice industry is mostly influenced by the government policy because the rice industry is smaller than other grain industries and most of the rice producing area is geographically concentrated.

Government payments for rice, including the value of PIK (Payment-In-Kind) rice, deficiency payment, and diversion payments, comprised more than 60 percent of total producer receipts from the 1986 and 1987 crop. Since 1980, the government expenditure to the farm value of rice production, excluding P.L.480 and other indirect payments, has increased significantly. Direct government payments to rice producers during 1980-1987 are shown in Table 1.1. In 1980, the ratio was less than 1 percent: Government direct payments totaled \$2 million and the farm value of rice production was a record \$1.87 billion. By 1983, however, the ratio rose to more than 40 percent: Government direct payments were estimated at \$618 million, but the farm value of rice production dropped to \$876 million. Payments were made to 19,538 farms and 31,624 farmers. The average payment per farm and farmers were \$31,925 and \$19,542, respectively. Arkansas, Louisiana, and Texas received nearly 75 percent of the total payments issued through government programs during this period. Since the Food Security Act of 1985, the ratio has increased significantly and reached more than 60 percent in 1986. As a result, the government policy, directly and indirectly, plays a leading and growing role in the U.S. rice industry.

Table 1.1: Ratio of Direct Payments to the Farm Value of Rice Production, 1980 – 1987[a]

Crop Year	Farm Value	Direct Payments	Total Income	Direct Payment as a Share of Total Income
		million dollars		percent
1980	1893	2	1875	0.11
1981	1654	22	1676	1.31
1982	1246	267	1513	17.65
1983	876	618	1494	41.37
1984	1119	380	1499	25.35
1985	881	721	1602	45.01
1986	520	1025	1545	66.34
1987	544	993	1537	64.61

[a]ASCS Commodity Fact Sheets for rice, 1977-1987, USDA.

Although domestic prices have been relatively stable under government programs, rice farmers and U.S. government have been giving more attention to the world rice market. The U.S. exports more than 60 percent of domestic rice production and has had an average share of about 20 percent of the world's rice exports.

The world rice market is inherently unstable with respect to price and sources of demand and supply. With a limited number of traders, one unexpected or new buyer can have dramatic consequences on trade, and hence on prices. Small swings in foreign demand can exert relatively quick and strong impacts on rice prices. A sudden upturn or downturn in demand of a key importer, or a seller unexpected as caught with a large exportable surplus and inadequate storage, will affect equally sharp price swings. For example, South Korea imported more than 1-million metric tons from the U.S. and more than 1-million metric tons from other small exporters in 1980, which encouraged world prices to increase sharply. And, a sudden increase in Indonesian exports discouraged major exporters, U.S. and Thailand, causing them to reduce their prices to maintain historical export levels.

Most nations that import rice also have protectionist policies that cushion their producers and consumers from the impacts of fluctuations in world market prices. Thus, the U.S., because of its relatively free trade practices and open agricultural markets, bears much of the burden of adjusting to changes in world trade. Small swings in the stream of imports can cause major changes in the cost of operating the U.S. rice program. Even if there exist high price-unresponsiveness in individual importing countries, the responsiveness of the aggregate excess demand functions can be quite high in a market with many importing countries (McCalla and Josling, 1985). As a result, small swings in foreign demand for world rice market are important to supply, demand, and price determination in the U.S. rice market as well as U.S. Government costs and U.S. farmers' expected returns.

A notable aspect of the international rice market is that Thailand, as the largest exporter and competitor to the U.S., has contributed to price and export variability in the U.S. rice market as well as in the world market. In short, the export policy of Thailand can have dramatic consequences on supply, demand, and prices in the U.S. rice market. Since rice is Thailand's highest valued agricultural commodity, highest valued export crop, and major foreign exchange earning (refer to Chapter 3), the Thailand government intervenes at many stages of rice production and trade (Vesdapunt et al. 1984). Interventions include input supply, market development, paddy price support, domestic milled price maintenance, and rice export control. However, the major form of government intervention is the rice export control policy, especially the rice premium, export tax, and rice reserve requirement. The overall objectives of Thailand's rice policy under the Fifth National Economic and Social Development Plan (1982-1986) remain almost unchanged from the period of the Fourth Plan (1977-1981), i.e., to raise rice production to meet increasing domestic consumption, to maintain exportable availabilities, to keep the domestic rice price low and stable, to earn government revenue from rice exports, and to change the export price of rice strategically for obtaining bargaining power in response to the changing international rice market situation (FAO, 1985). In order to achieve these objectives, the Thailand government has been imposing a rice export tax, among other things. As mentioned by USDA, ERS (Rice, Situation and outlook yearbook, 1988), when Thailand prices declined due to a reduction in the tax, the U.S. had to make a sharp downward price adjustment to remain competitive. Thailand's changed export-oriented policies undercut the U.S. exports. Thus, the policies of Thailand government play a crucial role in the U.S. rice market.

1.1 Objectives

The general objective of this study is to develop an economic model for evaluating the effects of policy on the U.S. rice market. More specifically the objectives are:

1) to develop the Stackelberg duopoly model in the world rice market in order to better understand the U.S. rice market, linked heavily with the world rice market.

2) to develop and estimate an econometric model of the U.S. rice market, with particular emphasis on explaining the simultaneous behavioral relationships among supply, demand, and prices.

3) to examine the dynamics of the supply and price formation process in the international rice market, and

4) to analyze effects of exogenous changes in the policy instruments such as U.S. support prices, the export tax of the Thailand government, and sudden changes in world demand on supply, demand, prices, U.S. government program costs, and the returns of rice farmers in the U.S. rice market.

1.2 Organization

The study is organized as follows: Chapter 2 presents a brief description of the U.S. rice economy. It reviews the structure of U.S. rice farms, the U.S. role in the world rice market, historical background for U.S. farm programs, and major relationships in the U.S. rice economy. In Chapter 3, a theoretical framework with U.S.

and Thailand policy mechanisms in the world rice market is illustrated. Structure and components of the model are developed in Chapter 4 to capture the impacts of policy alternatives, and world demand fluctuations on the U.S. rice economy. Chapter 5 reviews the estimation procedure, the final estimated equations, and interpretations of the results. Validation tests of the estimated model are treated in Chapter 6. Chapter 7 analyzes the impacts of policy alternatives and world demand fluctuations on the U.S. rice market. The impacts are evaluated through dynamic simulation analysis using the estimated model described in Chapter 5 and the base simulation results. Hypothetical changes in policies and world demand are introduced to perform dynamic simulations. A comparison of the simulation results with the base simulation results is used to show the impact of these changes. Finally, a summary and conclusions of the research and suggestions for further research are presented in Chapter 8.

2 U.S. RICE ECONOMY

Rice ranks ninth among major field crops in value of production and more than sixty percent of U.S. rice production is exported to the rest of the world. Most of total U.S. rice crop is produced by six states (Arkansas, Louisiana, Mississippi, Texas, Missouri, and California). Florida, Oklahoma, South Carolina, and Tennessee are the minor producing states, but the share of these states is less than one percent of total U.S. production. In four southern states (Arkansas, Louisiana, Mississippi, and Texas) rice comprises 10 percent of the field crop value. Altogether, the six rice producing States supply from 18 to 25 percent of the world's rice exports. Domestic food consumption is small in comparison with other cereal foods. For example, food consumption of both wheat and rice accounts for roughly a third of total domestic use of these cereals. But, domestic consumers consume eight times as much wheat as rice. The U.S. is the second largest rice exporter, next to Thailand. The high ratio of exports to domestic use makes the U.S. rice industry heavily dependent upon the world rice market.

2.1 Structure of Rice Farms

According to the 1978 Census of Agriculture, 10,849 farms harvested just over 3 million acres of rice and all acreage was irrigated. Table 2.1 shows that the

Table 2.1: Number of Farms by States and Share of Output, 1978[a]

State	Number of Farms	Share of U.S. Output	Acreage Size	Acreage Yield per Acre
Arkansas	4,732	35.9	228	4,447
Louisiana	2,732	16.8	220	3,742
Mississippi	579	6.8	373	4,243
Texas	1,393	20.8	429	4,652
Missouri	153	0.8	163	4,095
South total	9,589	81.1	263	4,307
California	1,258	18.9	386	5,219
Total[b]	10,849	100.0	277	4,454

[a]USDA, ERS. 1984. Rice, Background for 1985 Farm Legislation.

[b]Includes some farms in minor rice-producing States; Florida, Oklahoma, South Carolina, and Tennessee.

average size of rice farms was 277 acres. Roughly 38 percent of the farms harvested 250 or more acres, and they produced three-quarters of the 1978 rice crop. Farms harvesting less than 100 acres of rice comprised more than a quarter of all rice farms, but contributed less than 5 percent of U.S. rice production. Arkansas has the greatest number of rice farms, but Texas and California has the largest farms. The average yield in 1978 was 4,454 pounds of rice per acre. Larger farms achieved the highest yields. Yields on farms of 1,000 or more acres averaged nearly 130 pounds an acre higher. Table 2.2 shows that the number of rice farms by size and share of output, 1978.

2.2 The U.S. Role in The World Rice Market

Normally, U.S. contributes 2 percent to the world rice production. In 1983/1984, because of a 30 percent PIK-induced decline in production, U.S. rice was just 1 percent of the world's production. Nevertheless, the U.S. will likely reclaim 18 percent of world rice trade, following the lead position of Thailand. In recent years, U.S. has provided almost 25 percent of the world's rice exports. Thus, while the U.S. rice crop is insignificant in comparison to world production, its impact on trade is large. Moreover, U.S. rice is a source of stability in an often volatile, unreliable world rice market. The entire U.S. rice crop is flood irrigated, promoting stable supplies. Production capacity is resilient and far outweighs domestic requirements. These factors, in addition to some government program provisions that help promote stability and intensive cultivation, assure a reliable supply of rice for export.

Major customers for U.S. rice exports have changed over the past 30 years (Table 2.3). Changes in political relations and improved production in foreign

Table 2.2: Number of Rice Farms by Size and Share of Output, 1978[a]

Acres of Rice Harvested	Number of Farms	Percentage of Total Farms	Percentage of Output	Acreage Yield per Acre
	number	percent	percent	pounds
1 - 99	2,969	27.3	4.8	4,306
100 - 249	3,745	34.5	20.0	4,394
250 - 499	2,561	23.6	28.9	4,377
500 - 999	1,201	11.0	26.9	4,522
1,000 or more	373	3.4	19.5	4,583
Total[b]	10,849	100.0	100	4,454

[a]USDA, ERS.1984. Rice, Background for 1985 Farm Legislation.

[b]Columns may not add to 100 percent due to rounding.

countries have redefined their positions from net importers to self-sufficiency or net exporters. In the 1950s, Cuba, India, Pakistan, and Indonesia were the biggest markets for U.S. rice. In the 1960s, India, Pakistan, and Indonesia remained strong markets, but demand for U.S. rice also grew in Western Europe, South Korea, South Vietnam, and South Africa. Japan was a significant importer of rice through 1966. By the end of the 1960s, India ceased importing U.S. rice and Pakistan became a major exporter. Relations were severed with Cuba early in the decade, ending rice trade, but markets opened in the Middle East and Africa.

During the 1970s, the Middle East and Africa developed into two of the strongest markets for U.S. rice. In the later case the increase was due in part to subsidized exports. Asian markets, with the exception of Indonesia, have come and gone throughout the decade. The European Community and Canada have remained stable but small markets for U.S. rice. During the 1980s, the U.S. has lost its market share in selected countries. The segment of the international market growing import demand for rice has shifted to Thailand on the basis of more attractive prices. For the first time in several years, it looks as though the U.S. has lost a premium market in Nigeria, previously large buyer of U.S. rice. Again, Nigeria, which has suffered a loss of foreign exchange, has not reduced its demand for rice, but turned to Thailand for cheaper rice to accommodate domestic demand.

2.3 Historical Background for U.S. Rice Farm Programs

Scarce supplies, favorable prices, and rapid improvements in production technology in the world following World War II resulted in a rapid expansion of rice acreage and production in the U.S. and abroad. In 1954, rice production exploded

Table 2.3. Top Five Customers for U.S. Rice, 1973-1985 Crop Year[a]

Country	73	74	75	76	77	78	79	80	81	82	83	84	85
S. Vietnam	1[b]												
Kampuchea	2[b]	4[b]											
S. Korea	3[b]	1[b]	2	5			1	1	2	3	5		
Saudi Arabia	4				4	3	4	3	3	2	1	2	2
S. Africa	5		5	4							3	5	
Iran		2	3	1	2	1							
Iraq		5				5	2		4	1	2	1	1
Bangladesh		3	1										
Indonesia				2	1	2	3	4					
Nigeria				3	3	4	5	2	1	4			
Italy					5				5				
Bel./Lux.										5	4	3	3
Peru								5					
Canada												4	5
Senegal													4
						percent							
Share of U.S. Exports	50.3	68.4	46.5	55.6	58.0	48.3	52.4	61.4	52.0	46.4	57.7	47.8	47.9

[a]USDA, Agricultural Statistics (various issues).

[b]denotes P.L. 480 customer. All others are commercial buyers.

to a record 64 million cwt, over twice the average during World War 2. However, with the expanding supplies and weak demand, world prices declined, and carry-over stocks surged to 27 million cwt, seven times greater than the average of the previous 3 years. World prices dropped and average U.S. prices received by farmers were below support prices. To maintain domestic prices the near support level, the Commodity Credit Corporation (CCC) made nonrecourse loans and accumulated large stocks of rice. Subsequent high domestic prices meant that traders could not export rice without absorbing a loss. As a result, U.S. exports declined sharply and carryover reached a high. All this led to adoption of a government program and export subsidy programs for rice.

During the period which land allotments, marketing quotas, and an export subsidy program for rice were in effect (1955-1973), prices received by farmers were stable and above support price levels.

During the 1970s, domestic use and exports of U.S. rice rose sharply while world prices were above the U.S. loan rates. In 1973, the average farm price was \$ 13.80 a cwt, compared with a support level of \$ 6.07. The Rice Production Act of 1975 reflected these changed conditions and shifted rice production control from allotments and quotas to greater market orientation along the lines of the programs for other grains. The export subsidy was also stopped at that time. A target price and direct (deficiency) payments were established. The allotments became the payment base. Farmers could now plant in excess of their allotments, but eligibility for loans and deficiency payments was restricted to rice from allotted acres.

During the 1980s, rice stocks again rose and prices fell because of the world rice market conditions (i.e., specially, Thailand export policy and slowed economic growth in importing countries). From the late 1950s, Thailand imposed domestic sales quotas and reduced the export tax. Hence, it had a restrictive export policy. However, in the early 1980s, Thailand adopted a more export-oriented policy and expanded its market share in the world rice market. Thus, the U.S. market share of world trade in the 1980s has been falling in comparison with that of Thailand. In Figure 2.1, the decline in U.S. rice exports since 1980 and at the same time the increase in Thailand rice exports are shown.

To solve the problems that rising production capacity, weak foreign demand for U.S. rice, hefty supplies and stocks, farm prices below target prices, and increasing government costs were causing, the Food Security Act of 1985 introduced greater market orientation in U.S. farm policy.

2.4 Major Relationships in the U.S. Rice Economy

Supply and demand relationships for rice are unusually complex chiefly because domestic prices, export prices, and utilization in several outlets are determined simultaneously not only by the supply of rice, but also by factors outside the rice market structure. The rice economy for the U.S. can be viewed as influenced by four sets of factors, those affecting 1) domestic production, 2) world production and price, 3) domestic utilization, and 4) exports.

Figure 2.2 illustrates the principal economic relationships and variables involved in the U.S. rice economy. The top of Figure 2.2 shows the forces affecting rice production, yield, and acreage. With land allotments (or other acreage programs) or price supports, such physical factors as weather, cultural practices, and insect-disease controls are often more important than economic forces in deter-

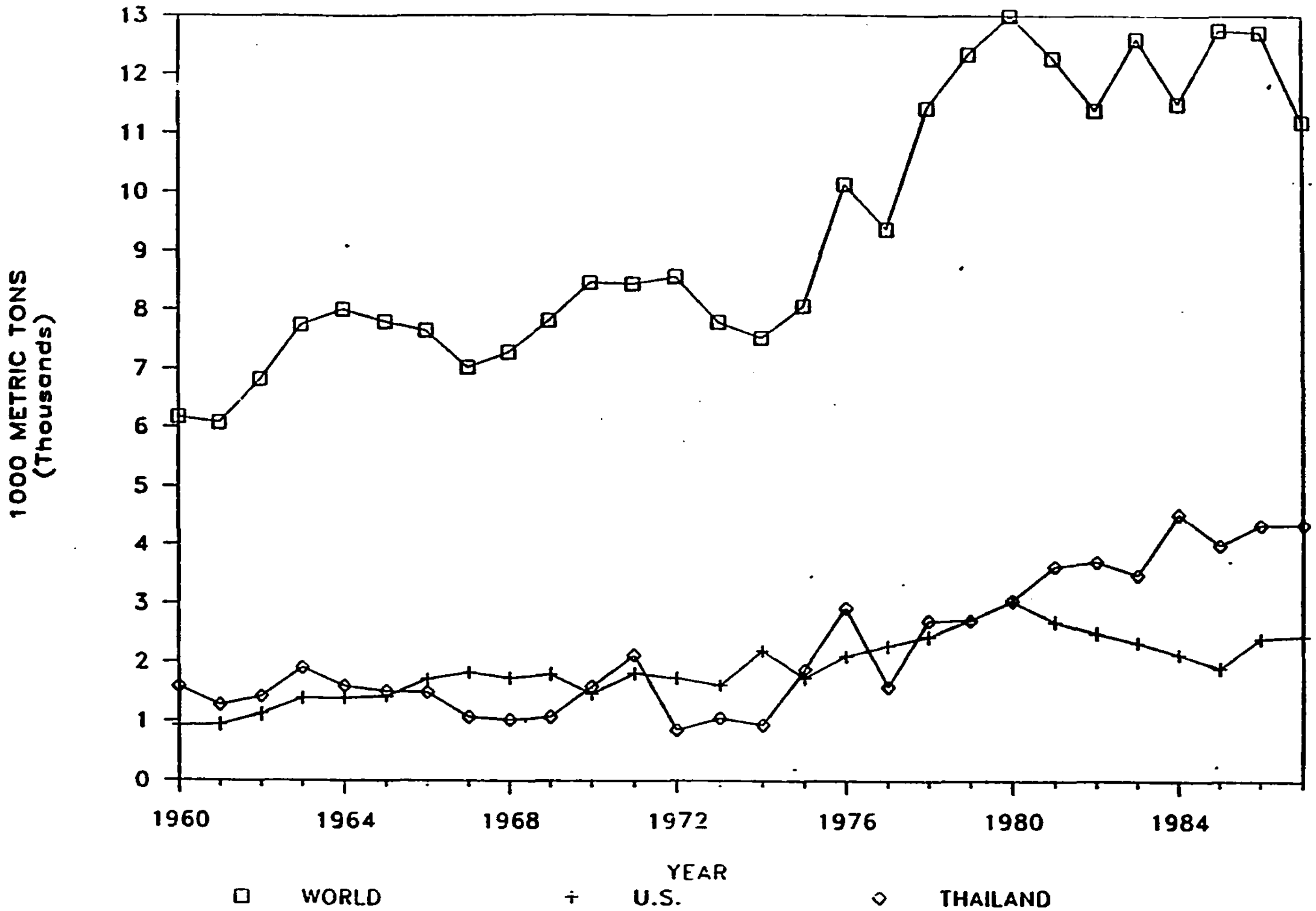

Figure 2.1: The Export Share of U.S. and Thailand

mining year-to-year changes in production. With allotments limiting acreage to specified levels and price supports stabilizing prices, rice producers have responded by adopting new cultural practices to increase yields. Under these conditions, the changing technology becomes a significant causal factors.

In the lower left of Figure 2.2 are indicated selected factors affecting world production, prices, and utilization. Knowing what factors determine the world price of rice is important to domestic producers, since the U.S. normally exports more than sixty percent of its rice production. Except when prices are supported by government programs, market (not support) prices received by domestic producers normally reflect the world supply and demand situation. Logically, the world price of rice is determined by the world supply, the quantity available for export, income and policies in the major importing countries, and the supply of competing grains (e.g., wheat). However, export policy of Thailand, as the largest export market supplier, played a crucial role in the world rice market as well as the U.S. rice market during the 1980s.

Domestic outlets indicated in Figure 2.2 are food, industry, seed, and carryover. Utilization levels in the first two outlets are assumed to depend partly on price, income, consumption trends (i.e., changes in habits and population), and partly on prices of competing commodities.

Trade in any commodity implies relative surpluses and deficits. In countries having an advantage in rice production, production in most years may exceed domestic requirements. This holds true for the U.S. which exports more than sixty percent of its production. U.S. exports are influenced by conditions at home and abroad (i.e., Thailand export policy) and by U.S. government programs.

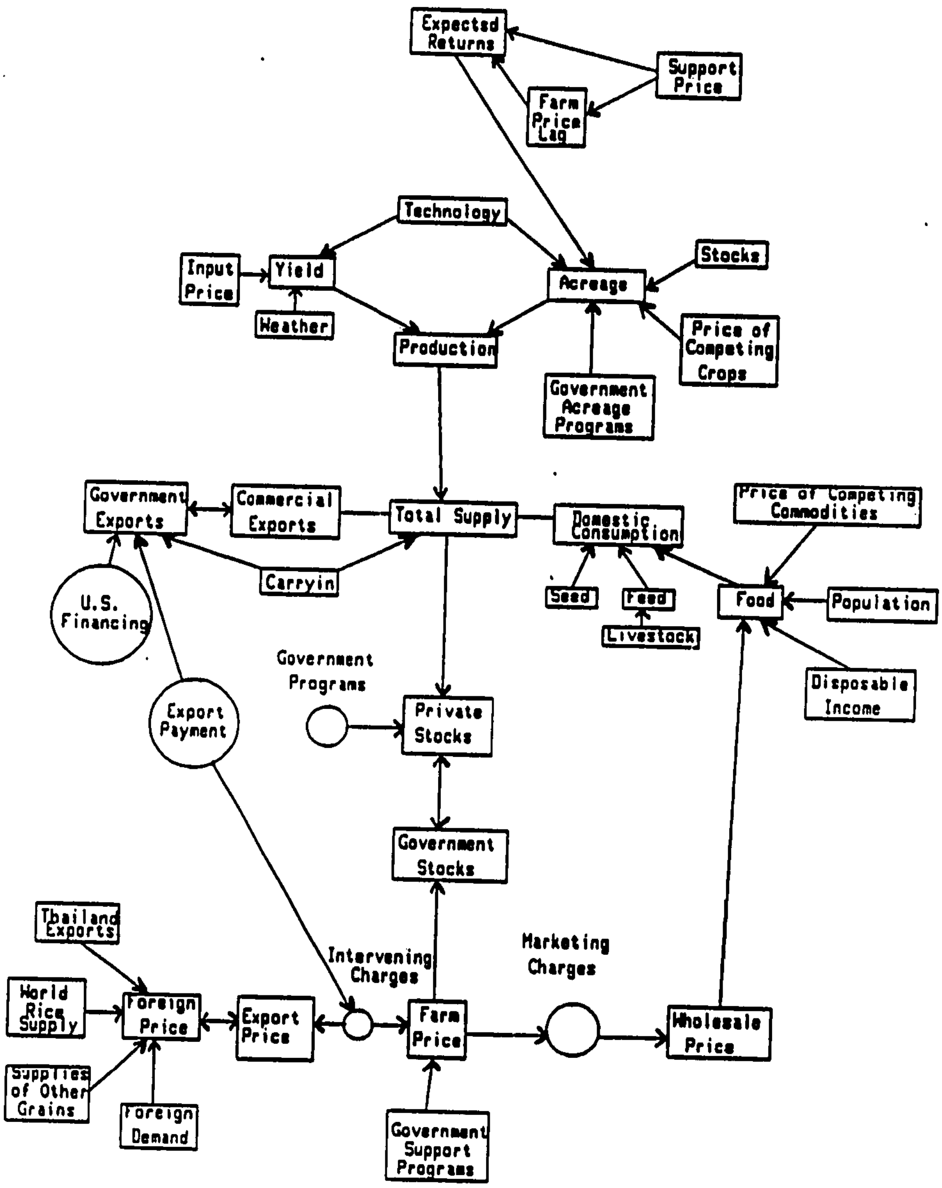

Figure 2.2: The Structure of the U.S. Rice Economy

3 THEORETICAL FRAMEWORK

3.1 Non-Cooperative Duopoly Model in the World Rice Market

Thailand is currently the largest rice exporting country with 30 percent of the market share, while the U.S. is the second largest rice exporter with 18-25 percent of the market share. As recently as the late 1970s, the U.S. and Thailand exported about 50 percent of world trade. During that period, Thailand imposed export taxes and domestic sales quotas for exporters. Hence, it had a restrictive export policy. In the early 1980s, however, Thailand adopted a more export-oriented policy and expanded its market share, because rice brought more than 20 percent of agricultural GDP at current market prices and around 30 percent of agricultural export earnings. The regulation of private export trade has been reduced with the abolition of the quota system (1980), the suspension of the rice reserve requirement in export taxes and in the export premium (1983). Moreover, exporters were helped by a further expansion of credit for their purchase of rice and of rediscount facilities for exports[1]. Meanwhile, the U.S. government also adopted more export-oriented policy. Among other things, a lower support price will lead to increase exports and to reduce government stocks.

[1] A comprehensive survey on the Thailand rice industry, including a policy review, is given by FAO, 1985; Economic and Social Development Paper 54.

This situation in the world rice market can be a kind of trade war as mentioned by Sampson and Snape (1980). The common approach to the issue applies the oligopoly analysis familiar to those acquainted with intermediate microeconomics. However, a duopoly approach rather than an oligopolistic approach is appropriate for the world rice market. Even though the U.S., Thailand, Burma, Pakistan, and China supply 65 to 70 percent of world exports, the U.S. and Thailand supply more than 50 percent of the markets, and only these two countries have storage facilities in sufficient volume to permit holding, an ability essential to duopolistic pricing. The behavior of others is more akin to that of the smaller exporters and can be characterized as following the price set by the duopolists. Following Paarlberg and Abbott (1986), U.S. and Thailand have potential market power because of substantial market shares and existence of institutions through which market power may be exercised.

Furthermore, price leadership by Thailand arises primarily[2]. Following McCalla (1966), the U.S. is willing to let Thailand lead and chooses to be a price follower, first because of the U.S. domestic agricultural policy, and second because of the U.S. foreign policy. While the Thailand government has direct control over all prices (domestic and export prices) and quantity, the USDA has indirect control over the market. State and private trading companies in the U.S. do not exercise their market power as the Thailand government does in the world rice market. Moreover, in terms of production capacity, production costs, available stocks, and

[2]Price leadership and appropriate market structure in the various world grain market were investigated by Alaouze et al. (1978), Carter and Schmitz (1979), Kolstad and Burris (1986), McCalla (1966), McCalla and Josling (1981), Mendulson (1957), and Paarlberg and Abbott (1986).

financial resources, Thailand is in the position to be a dominant price leader. For example, an average farm price of rice in the U.S. is four times higher than that in Thailand during the period of this study. It implies that Thailand faces lower production costs than U.S. does so that Thailand has absolute advantage in the world trade [3]. As the result, a duopoly approach under price leading is appropriate for world rice market.

The following model explains this type of price arrangement of exporters' market power (i.e., Stackelberg duopoly model). Consider a market in which two firms, Firm 1 and Firm 2, produce a homogenous product. The inverse demand function states price as a function of the aggregate quantity sold:

$$P = P(Q_1 + Q_2) \tag{3.1}$$

where Q_1 and Q_2 are the level of the duopolists' output. The total revenue of each duopolist depends upon his own output level and that of his rival. So, the profit of each equals his total revenue less his cost, which depends upon his output level alone:

$$\Pi_1 = P(Q_1 + Q_2) \cdot Q_1 - C_1(Q_1) \tag{3.2}$$

$$\Pi_2 = P(Q_1 + Q_2) \cdot Q_2 - C_2(Q_2) \tag{3.3}$$

Setting the appropriate partial derivatives of (3.2) and (3.3) equal to zero,

$$\frac{d\Pi_1}{dQ_1} = P + Q_1 \frac{\partial P}{\partial Q}(1 + \frac{\partial Q_2}{\partial Q_1}) - \frac{\partial C_1}{\partial Q_1} = 0 \tag{3.4}$$

[3]Siamwalla and Stephen (1983) argued that the areas of mainland Monsoon Asia have a comparative advantage in rice production with the traditional low-input technology as a consequence of their favorable man-land ratio.

$$\frac{d\Pi_2}{dQ_2} = P + Q_2\frac{\partial P}{\partial Q}(1 + \frac{\partial Q_1}{\partial Q_2}) - \frac{\partial C_2}{\partial Q_2} = 0 \tag{3.5}$$

The terms $\partial Q_2/\partial Q_1$ and $\partial Q_1/\ \partial Q_2$ represent the 'conjectural variation', i.e., the assumed response of each firm to its rival's output. Since the Cournot solution is obtained by maximizing Π_1 with respect to Q_1, assuming Q_2 to be constant, and Π_2 with respect to Q_2, assuming Q_1 to be constant, the conjectural variation is equal to zero. i.e., $\partial Q_2/\partial Q_1 = 0$ and $\partial Q_1/\partial Q_2 = 0$. Solving (3.4) yields Firm 1's reaction function,

$$Q_1^c = f(Q_2) \tag{3.6}$$

Similarly, solve (3.5) for Firm 2's reaction function,

$$Q_2^c = g(Q_1) \tag{3.7}$$

Reaction functions express the output of each duopolist as a function of his rival's output. Solving the reaction functions simultaneously yields the Cournot solution.

One of the more interesting sets of assumptions about conjectural variation is contained in the analysis of leadership and followership formulated by Stackelberg. Suppose we assume Firm 2 is the leader and Firm 1 is the follower. The follower, Firm 1, obeys his reaction function (3.6) and adjust his output level to maximize his profit, given the quantity decision of his rival. The leader, Firm 2, does not obey his reaction function. Firm 2 assumes that Firm 1 acts as a follower, and maximizes his profit, given Firm 1's reaction function.

Firm 2 uses Firm 1's reaction function, (3.6), to determine optimal output Q_2. Substitutes (3.6) into his profit function (3.3).

$$\Pi 2 = P(Q_1 + Q_2) \cdot Q_2 - C_2(Q_2) \tag{3.8}$$

$$= P[f(Q_2 + Q_2] \cdot Q_2 - C_2(Q_2) \qquad (3.9)$$

Firm 2's profit is now a function of Q_2 alone and can be maximized with respect to this single variable.

$$\frac{d\Pi_2}{dQ_2} = P[f(Q_2) + Q_2] + Q_2 \cdot \frac{\partial P}{\partial Q}(\frac{\partial f}{\partial Q_2} + 1) - \frac{\partial C_2}{\partial Q_2} = 0 \qquad (3.10)$$

where $\partial f/\partial Q_2$ is the slope of Firm 1's reaction function. Solving equation (3.10) yields Stackelberg leader output, Q_2^s and substituting Q_2^s in Firm 1's reaction function (3.6) yields Firm 1's follower output, Q_1^f.

3.2 Impacts of Thailand Export Policy on U.S. Rice Market

Now we apply the Stackelberg duopoly model to the world rice market and are concerned with how a leader's price policy affects a follower's market. The analysis is presented in Figure 3.1. As we assumed, Thailand is a leader and U.S. is the follower in the world rice market.

Thailand supply is S_t. Let ED_{row} be the summation of net export demands facing duopolists, Thailand and the U.S. The U.S. supply is S_{us}. Also, let us assume that Thailand is willing to let the fringe sell all they can at whatever price Thailand sets. In other words, the fringe can sell what the U.S. does not want to sell at the price Thailand sets. Therefore, the demand function facing Thailand is D_t which is the horizontal subtraction of S_{us} from ED_{row}. If Thailand wants to maximize national returns it equates the marginal revenue (MR_t) to supply (S_t) to determine the optimal output Q_t. Thailand charges P_w which is world price. At that price the U.S. sells OQ_{us}. This plus $OQ_t(= Q_{us}Q_w)$ satisfies world demand of Q_w. Thailand is better off compared to the competitive situation P_c because the

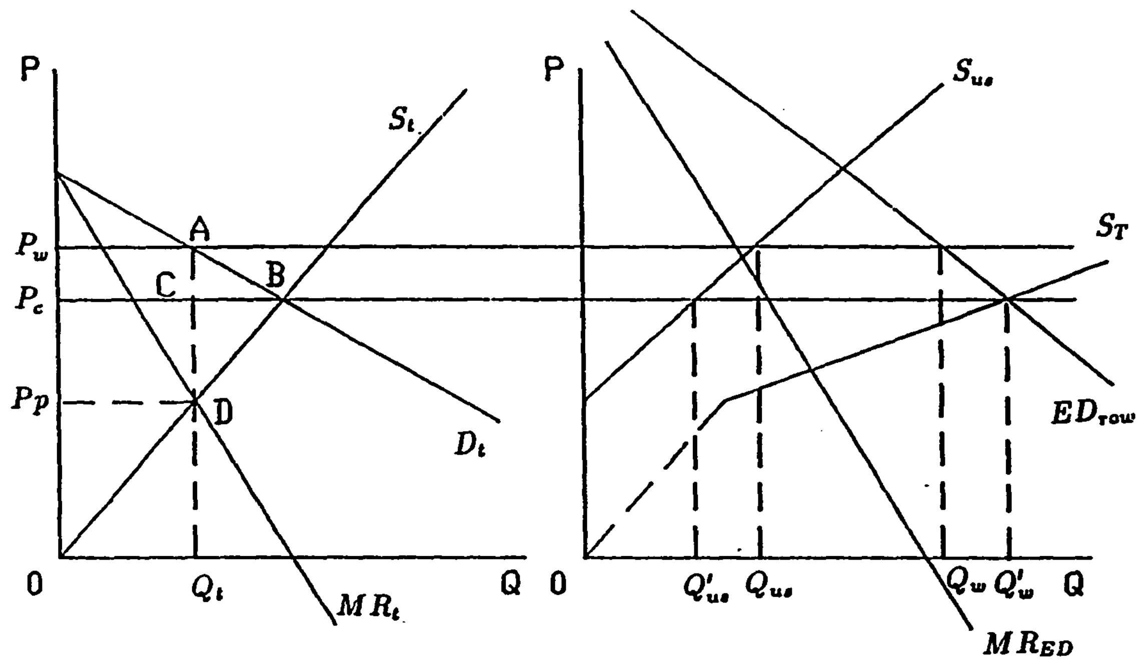

Figure 3.1: Determination of Stackelberg Solution for World Rice Market

net loss in producer surplus (BCD) is more than offset by the net gain in monopoly rent $P_w ACP_c$. Also, the fringe is better off selling a large quantity at a higher price. Consumers globally are worse off.

If producer price is set at P_p, however, Thailand government can charge an export tax equal to $P_w - P_p$. Or a mandatory supply control program could be implemented to restrict supply to Q_t. The Thailand government uses the policy of a combined export tax and the quota system.

Based on the duopoly market structure discussed above, how does the export-oriented policy of the Thailand government affect the U.S. rice market? Since the early 1980s, the Thailand government has been adopting a more export-oriented policy and expanding its market share. Therefore, effects of cutting export taxes by the Thailand government on the U.S. rice market will be discussed.

Suppose the Thailand government reduces the export tax from $P_w - P_p$ to $P_c - Pp$ by setting the export price at competitive levels. Then Thailand can export more, from $Q_{us}Q_w$ to $Q'_{us}Q'_w$, and the U.S. exports, less from OQ_{us} to OQ'_{us}, because of the lower export price. Figure 3.2 represents how reduction of Thailand export taxes affects the U.S. domestic market. U.S. export demand shifts down because Thailand occupies some portion of the U.S. export share by cutting its export tax. This result corresponds to a leftward shift of the market demand curve in Figure 3.2 from D_0 to D_1 and a decrease of the farm price from P_0 to P_1. The decrease in market price induces the incentives of the domestic consumer to consume and of the stock-holder to have more stocks. And the decrease in market price reduces the incentive of farmers to plant.

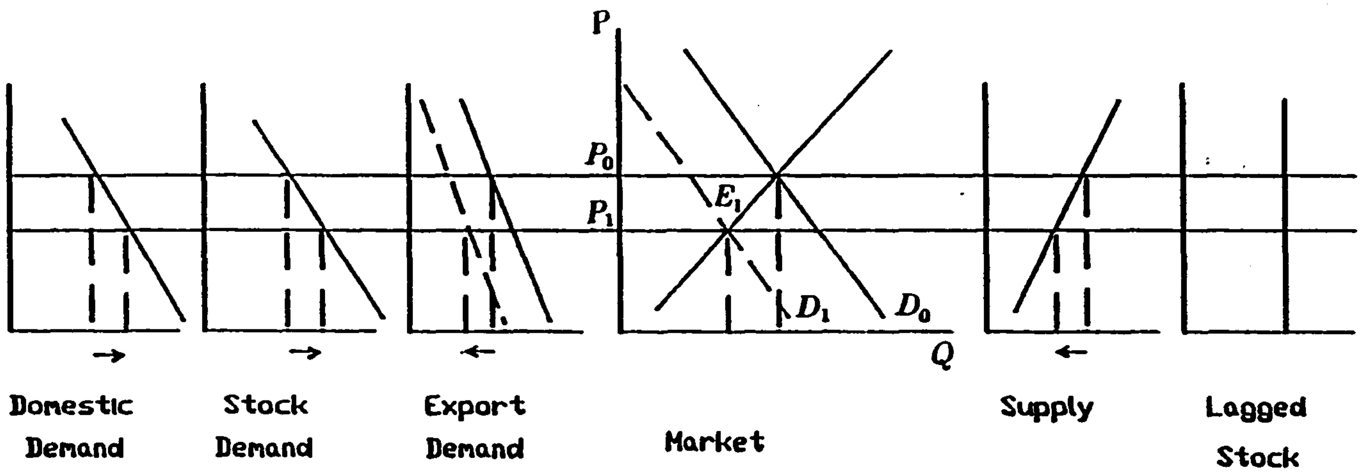

Figure 3.2: The effects of Thailand export tax decrease on U.S. rice market.

3.3 Impacts of Foreign Demand Fluctuations on U.S. Rice Market

With a basic duopoly model as discussed in the previous section, it is straightforward to explore the determination of foreign demand shocks in world rice markets. Suppose major importing countries (see Table 2.3) had sudden increases in the total production in a given year[4], which implies sudden decreases in import demand, thus shifting the excess demand curve facing Thailand and the U.S., ED_{row}, to ED'_{row} in Figure 3.3. Assumptions and notations are the same as those described before. To maximize national returns, Thailand equates the new marginal revenue (MR'_t) to supply (S_t) to determine the optimal output, Q'_t. Thailand charges P'_w which is the new world price. At that price the U.S. sells OQ''_{us}. This plus OQ'_t (= $Q''_{us}Q''_w$) satisfies the new world demand of Q''_w. Both Thailand and the U.S. are globally worse off because of the lower world price, P'_w, and less exports.

Once the quantity of U.S. export share is set at OQ''_{us} through changes in prices in the world market, transmission of foreign demand shocks in the U.S. rice market can be analyzed. Figure 3.4 represents how reduction of foreign demand in the world market affects the U.S. domestic market. U.S. export demand shifts down because of lower export prices and less world demand. This result corresponds to a leftward shift of the market demand curve in Figure 3.4 from D_0 to D_1 and a decrease of farm prices from P_0 to P_1. The decrease of market prices induces the incentives of domestic consumers to consume and of stock-holders to have more stocks. And the decrease of market prices reduces the incentive of farmers to plant.

[4]The factors contributing heavily to the increase in production might be abnormally favorable weather, improved rice varieties, and new technology (see Grant et al., 1980).

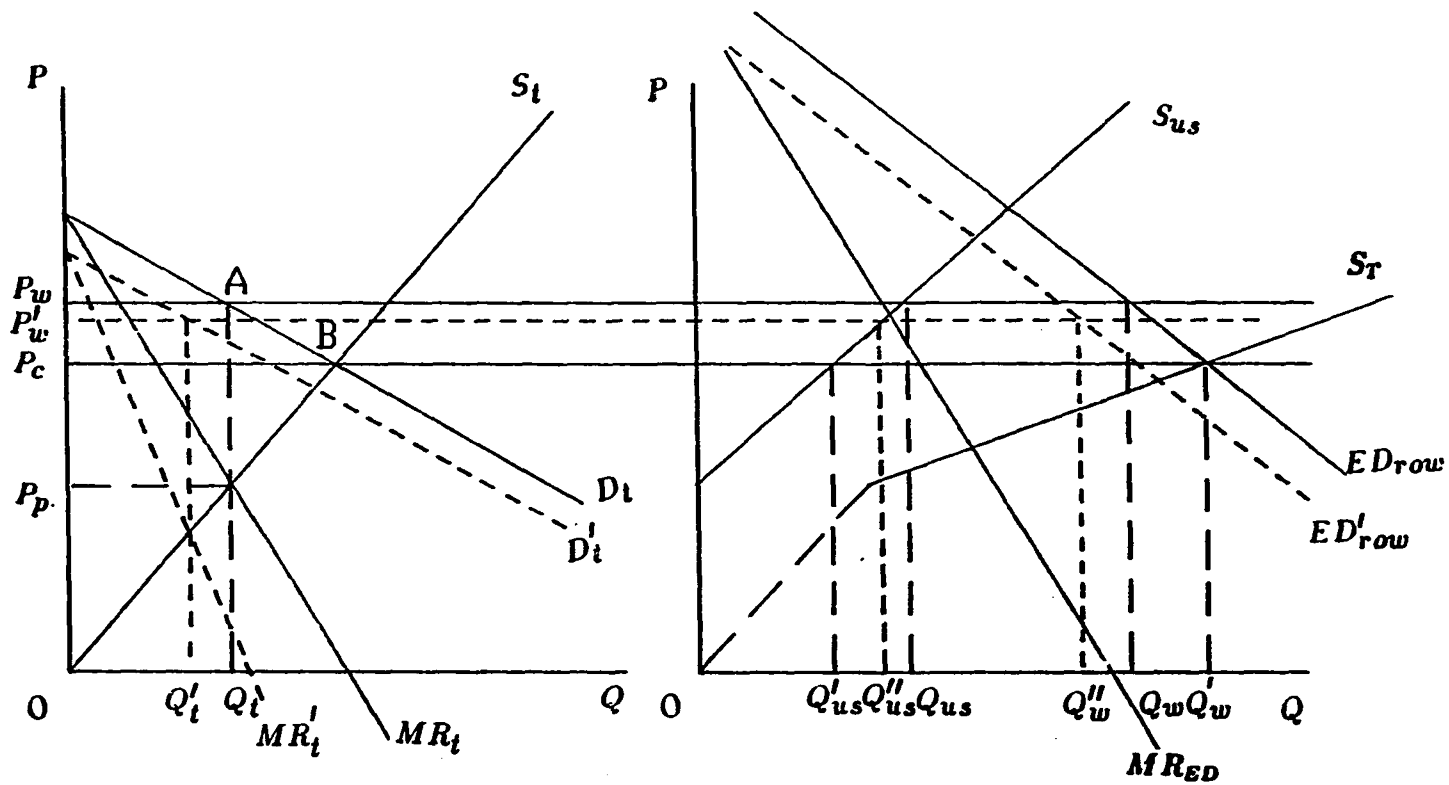

Figure 3.3: Graphical Representation of Foreign Demand Shocks in Duopoly Model

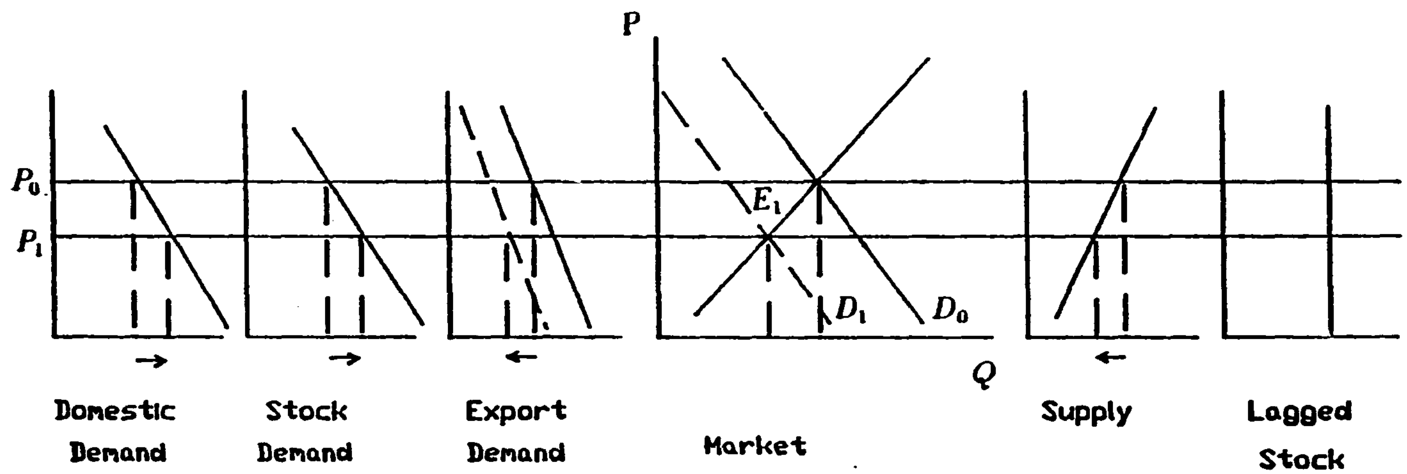

Figure 3.4: The Effects of Foreign Demand Decrease on U.S. Rice Market

3.4 Impacts of Price Support Policy on U.S. Rice Market

Government commodity programs in the U.S., including rice, have both direct and indirect effects on farmers, consumers, and taxpayers. Specifically, the rice program affects 1) prices received by farmers and paid by foreign consumers of rice, 2) incomes of farmers and taxpayers, 3) resources - specifically, land and other inputs used to produce rice, 4) quantity of rice demanded domestically and abroad, and 5) foreign production and exports of competitors.

The mechanisms currently used to achieve objectives of the farm programs, among others, include nonrecourse loans, a deficiency payment scheme, and acreage controls.

Nonrecourse loans are 9 to 12 month loans which the government makes available to farmers at a specified loan rate per unit of production. The farmer's crop is used as collateral. When the loan reaches maturity, the farmer may repay it, plus interest, in cash, or repay it in-kind using his crop. This program is an example of a 'minimum price scheme' in which the government maintains a floor price to both producers and consumers by acquiring or disposing of stocks of grain. Deficiency payments are made to rice producers when the average market price over the first five months of the marketing year falls below a specified 'target price'. The payment per unit of production is the difference between the target price and the maximum of the market price and the rate at which nonrecourse loans are made available. To qualify for deficiency payments producers may be required to reduce their planted acreage from an assessed base level. Land diversion payments, in cash or in kind, may be received by farmers for land removed from production under this program.

However, increasing government stocks and decreasing exports leads USDA to adopt more market-oriented policy by reducing support prices under the Food Security Act of 1985 (FSA85). Loan rates for the major program commodities have been dropped to minimum allowable levels, acreage reduction requirements have been increased, and generic payment-in-kind certificates have been used to make up a high proportion of government payments to farmers. Minimum target prices were set at \$ 11.90, and \$ 11.66 per cwt for the crop years 1986-1987, respectively, and subsequently will be reduced by 10 percent, guaranteed that gross receipts from crops and net farm income would remain at a nominal value comparable to that achieved on average during the 1981 Farm Bill.

Lots of analysts argued that rigid price supports and unrealistically high target prices were simply not appropriate to the economic condition that merged in the 1980s (Rodgers, 1985). To say, agricultural economists repeatedly argue as to what the appropriate forms of policy instruments, such as support levels, should be. The optimal setting, whatever it may be, should be defensible. This study, however, will not attempt to investigate such issues. In contrast, the existing agricultural policy instruments in the rice market, support levels, are analyzed.

How target prices affect the rice market will be demonstrated by constructing an annual econometric model of the U.S. rice market. The target price affects other endogenous variables in the model through the planted acreage equation, which depends upon, among other things, expected gross returns per acre. Rice producing farmers are concerned with their expected returns rather than expected prices. This is done because when rice producing farmers make decision for planted acreage, they would give more attention not only to expected prices but also to expected production costs and expected yields. Expected gross return is determined by the three-year moving average of expected net returns. Expected net returns is modeled as maximum (expected farm price, loan rate) times expected yield minus variable costs plus the deficiency payment per acre. The expected payment rate for the deficiency payment is modeled in this study as the difference between the target price and an expected price. The expected price is either a farm price prior to planting or the loan rate, whichever is higher. If no acreage limitation program is announced, the deficiency payment will act as an incentive for qualified farmers to produce more even though there may not be other strong market signals for them to do so.

The partial analysis for the changes in target price, as opposed to general equilibrium analysis, is represented by graphs in Figure 3.5. The decrease of target prices reduces the incentives of farmers to plant owing to a decrease in the expected gross returns. Consequently, a smaller supply of rice is expected. This result corresponds to a leftward shift of the supply curve in Figure 3.5 from S_0 to S_1 and an increase of farm prices from PF_0 to PF_1. Given milled demand unchanged, milled prices increase from PM_0 to PM_1. Thus, quantity of milled demand exports, food use, and inventory decrease.

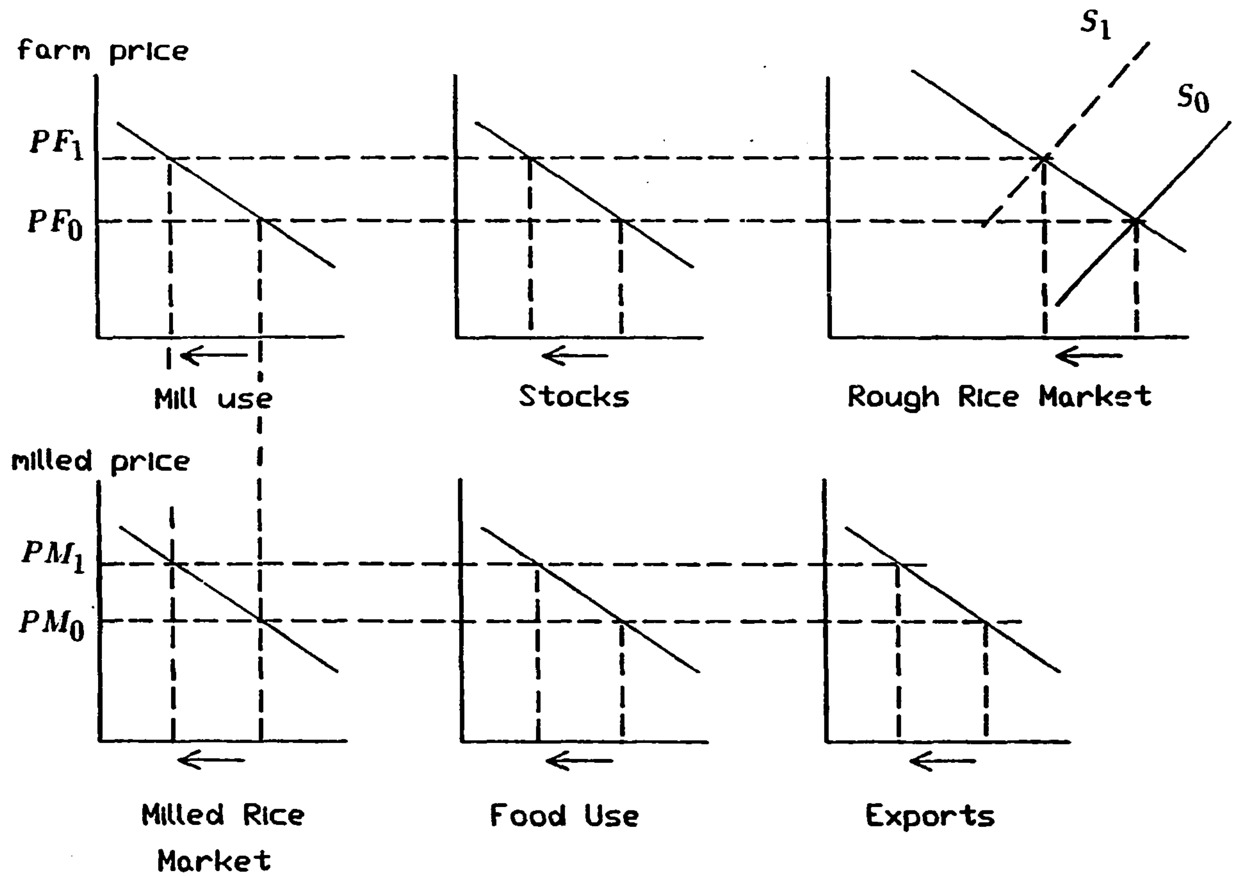

Figure 3.5: Graphical Representation of a Decrease in the Supply

4 STRUCTURE AND COMPONENTS OF THE MODEL

The domestic and world economies of food and agriculture have become increasing complex over the last few decades due to economic and noneconomic factors (i.e., domestic and foreign price instabilities, government administrative instability, inflation, and trade regulation etc.). Specifically, the supply-demand price relationships for rice are complex because of the diverse of demand and supply characteristics of the rice market. Prices and uses of rice products are determined simultaneously, not only by the supply of rice, but also by certain factors outside the market structure that affect demand (Grant et al. 1984). The increasing widespread use of commodity models for rice reflects not only our deeper understanding of these complexities of the market, but also our ability to measure the various influences which economic and noneconomic factors exert in the market.

The development of useful decision-making models for dynamic systems of the type represented by the agriculture and food economy requires the construction of conditional policy forecasts. In many situations, the construction of forecasting frameworks will also require the development of descriptive as well as explanatory models[1]. To ascertain the effect of alternative policies in terms of performance mea-

[1] Johnson and Rausser (1977) classified models in a number of ways. A particularly useful classification criterion is based on model objective. Depending upon research objectives, the researcher may use descriptive, explanatory, predictive and/or

sures, causal relationship between the decision variables and relevant performance measures must be captured (Rausser and Just, 1981).

This chapter provides the conceptual framework of the model and general specifications based on the theory and knowledge of economic relationships in the U.S. rice industry, which is discussed in an earlier chapter. The model determines acreage planted, acreage harvested, yields, total production, food consumption, commercial exports, commercial stocks, farm price, wholesale price, retail price, export price of the U.S., export price of Thailand, expected returns of rice, and government costs for rice endogenously.

4.1 Acreage Planted

$$RCAPUS = F1[RIAALU9R, RCERUS, RISK, Z_1] \tag{4.1}$$

where

RIAALU9R = Rice, Land Allotments

RCNRUS = Rice, Expected Net Returns

RISK = Rice, Risk Variable

Z_1 = Dummy Variables

During the period 1955 - 1977, land allotment and marketing quotas were in effect. As allotments restrict acreage, RIAALU9R lies between 0 and 1. After 1973, RIAALU9R = 1 because this program did not continue. Even though the 1981 Act repealed the rice allotment and marketing system, allotments no longer re-

---

decision models.

flected actual planting patterns (USDA, ERS, 1984. Rice, Background for 1985 Farm Legislation). However, the acreage reduction program (ARP) was introduced as a more specific acreage control method. When in effect, the ARP requires land to be diverted from a farm's rice base acreage and put into approved conservation uses. Compliance was required for eligibility for loans and deficiency payments. So acreage diversion variable will be used in this equation after 1981.

Following Langley (1983), expected gross returns which is a three-year moving average of expected net returns, instead of price variable, is introduced in the acreage equation. Net returns per acre at time t is

$$\begin{aligned} RCNRUS &= [(RCYHUS^e * Max(RCFPUS^e, RCLRUS)] \\ &\quad -RCCOUS + RCDPRUS \qquad (4.2) \end{aligned}$$

where

$RCYHUS^e$ = Expected Yield per Acre

$RCFPUS^e$ = Expected Farm Price

RCLRUS = Announced Loan Rate

RCCOUS = Rice, Variable Costs per Acre

RCDPRUS = Rice, Deficiency Payments Rate

The deficiency payment is determined by a formula: deficiency payment equals farm program acreage times farm program yields times payment rate. The expected payment rate for the deficiency payment is modeled in this study as the difference between the target price and an expected price. The expected price is either an expected farm price or the loan rate, whichever is higher. The effect of U.S. price support program (i.e., the target price and the loan rate) on other endogenous variables will be discussed through the acreage planted equation, which depends upon, among other things, expected net returns per acre.

The next component in the acreage planted equation is the RISK variable. Some econometric acreage response investigations include a risk variable. Developments in the economics of risk have provided some analytical tools in the analysis of stabilization benefits (e.g., Newbery and Stiglitz, 1981; Pope, Chavas, and Just, 1983). Empirical work has also addressed the influence of risk on agricultural production and distribution. Previous empirical research indicates, presumably because of risk aversion, that increases in price instability or income instability tend to decrease aggregate supply (e.g., Just, 1974; Lin, 1977; Hurt and Garcia, 1982) and to increase marketing margins (e.g., Brorsen et al. 1985 ; Grant et al. 1984). Brorsen et al. (1987) considered the influence of risk variables in a market equilibrium framework using a structural econometric model of the U.S. rice industry.

A relatively simple method to represent risk is a measure of dispersion about a mean level (e.g., a moving standard deviation of prices or returns). The risk variable in this equation is specified as the square root of a weighted moving average of the squared deviation of actual net returns from expected net returns. Expected net returns is considered to be last year's net returns. We use a three-year lag, which is fairly standard in acreage response studies (e.g., Just, 1974; T. Ryan, 1977). Thus, the measure of risk in supply is

$$RISK_t = [\textstyle\sum_{i=1}^{3} a_i(RCNRUS_{t-i} - RCNRUS_{t-i-1})^2]^{\frac{1}{2}}$$

where the weights selected (a_i) are arbitrary (i.e., $\frac{2}{3}$, $\frac{1}{4}$, $\frac{1}{12}$).

Since the inauguration of the target price program in 1976, direct payments have made up an increasing share of producer incomes and lowered acreage planted. During 1977 Government expenditures were about 128 million dollars for the direct price support or deficiency program. However, sharply decreasing farm and export prices in 1976 resulted in low acreage planted in 1977. Furthermore, the higher Thailand export price of rice in 1980 resulted in lower exports for Thailand and higher U.S. rice exports. South Korea, for example, imported more than 1-million metric tons from the U.S. in 1980. As a result acreage passed the 3-million mark for the first time in 1980 and reached a record 3.8 million in 1981. So dummy variables for 1977 and 1981 are adopted. Furthermore, the payment-in-kind (PIK) acreage reduction program in 1983 sharply reduced rice acreage by removing 1.2 million acres from production. A dummy variable for 1983 was used in the acreage equation to reflect this policy.

4.2 Acreage Harvested

$$RCAHUS = F2[RCAPUS] \tag{4.3}$$

Since production is equal to harvested acreage times yield, the planted acreage in the model must be transformed to acres harvested.

4.3 Yields

$$\begin{aligned} RCYHUS &= F3[RCADUS, RIAALU9R, RCCOUS, \\ &\quad YEAR, RAINFALL, DUM73] \qquad (4.4) \end{aligned}$$

The yields equation contains acreage diversion, land allotment, production cost, weather, trend, and dummy variable. Acreage diversion and land allotment variables are used in the equation to reflect the land area devoted to rice production. Economic theory indicates that acreage increases have negative impacts on yield due to limited capital and human resources in the short run and bring marginal land into rice production. Therefore, acreage diversion and land allotment should have positive effects. Production cost and trend variables are also included in this equation. It is well known that increasing production costs causes yields to decrease. Trend variables have a positive impact due to development of new technology. With government farm commodity programs, a physical factor such as weather is sometimes more important in determining year-to-year changes in production than economic forces are. Thus, a rainfall variable is included in the equation. A dummy variable is used for 1973 because of oil shocks.

4.4 Total Production

$$RCTPUS = RCAHUS * RCYHUS \qquad (4.5)$$

The production of rice is expressed as the product of area harvested times yields per acre.

4.5 Food Consumption

We can specify the food demand equation from a straightforward application of consumer demand theory, which shows the outcome for a utility-maximizing consumer who faces known prices and a fixed income when making commodity purchase decisions (Henderson and Quandt, 1980). Demand depends on the commodity price, the prices of substitutes (i.e., potatoes, corn, and wheat for rice), and income. Hence, an individual's rice demand ($RCFOUS_i$) is functionally related to rice retail price, prices of substitutes, and income:

$$RCFOUS_i = F5[RCMPUS, MPS, DPI_i] \tag{4.6}$$

where

RCMPUS = Rice, Retail Price

MPS = Prices of Substitutes

DPI_i = Personal Disposable income

Under the assumption of identical consumer tastes, market demand (RCFOUS) can be written in terms of population and individual demands:

$$RCFOUS = POPUS * F5[RCMPUS, MPS, DPI_i]^2 \tag{4.7}$$

or

$$\frac{RCFOUS}{POPUS} = F5[RCMPUS, MPS, DPI_i] \tag{4.8}$$

[2]This specification restricts the population elasticity at one, thereby avoiding multicollinearity between population and income.

where

POPUS = Population in the U.S.

4.6 Commercial Exports

$$RCCEXUS = F6[(\frac{RCEPUS}{RCEPTH}), WEGIN, WHEPUS, RCGEXUS] \qquad (4.9)$$

where

RCEPUS x = Rice, U.S. Export Price

RCEPTH = Rice, Export Price of Thailand

WEGIN = Weighted Income of Major Importing Countries

WHEPUS = Wheat, U.S. Export Price

RCGEXUS = Government Exports

This equation includes relative export price, weighted income of major importing countries, wheat export price, and Government exports. The relative export price is obtained by calculating the ratio of the U.S. export price of rice with the export price of Thailand rice because the U.S. export price and the Thailand export price of rice are highly correlated in the world rice market. Each is affected by government programs in the respective countries. The ratio of these prices was assumed to influence U.S. commercial exports. Weighted income growth of major importing countries (WEGIN) also influences the demand for U.S. commercial exports. WEGIN was calculated by income growth of major importing countries weighted by the amount of imports. The import substitute food grains are wheat and rice in the world market. Wheat as well as rice is a staple food in the developing and under-developing countries, and these countries import substantial quantities of U.S. rice. Thus, wheat export price of U.S., as a proxy for world price, is included in this equation.

4.7 Commercial Stocks

$$RCPSUS = F7 \; [RCFPUS, NIR, RCSUUS, RCTPUS_t, Z_7] \tag{4.10}$$

where

RCFPUS x = Price Received by Farmers

NIR = Normal Interrest Rate

RCSUUS = Target Price

$RCTPUS_t$ = Rice, Total Production

Private stocks are specified as a function of farm price, interest rate, government policy variable (target price), and total production. Private stocks will generally be negatively related to current farm price, since lower prices make it more likely one can sell later at a profit. That is, the higher the current price, the less likely that future prices will be high enough to give a capital gain on the stocks.

Interest rate has also a negative effect on stocks. The negative coefficient for interest rate reflects the opportunity cost of higher interest rates in storing the crop inventories. Thus, it captures the stocks effect of higher interest rates leading to a reduction in the crop storage.

Total production also affects carryover stocks because some portion of increased production usually remains in stocks.

Boehlje and Griffin (1979) pointed out that expected farm prices with a government program is higher than expected farm prices without the program. Therefore, a higher support price announced by the U.S. Government indicates a higher future price. Grant et al. (1984) also pointed out that stocks are influenced by government programs. Thus, a target price variable is included and expected to have positive impact in the equation.

Dummy variables are included to account for irregular increases in private stocks. After the 1973 export boom private stocks increased sharply because of decreasing export demand. The sharply decreasing price of rice in 1982 also influenced large amounts of carryover stocks. Therefore, dummy variables are used for 1975 to 1982 in this equation.

4.8 Market - Clearing Identity

$$
\begin{aligned}
RCTPUS \quad + \quad & LAG(RCPSUS) + LAG(RCGSUS) = \\
& RCFOUS + RCCEXUS + RCGEXUS \\
& + RCPSUS + RCGSUS + RCOTUS \qquad (4.11)
\end{aligned}
$$

Equilibrium in the rice market requires that the total supply of rice at time t is equal to total demand of rice at time t. Total supply is defined as current total production plus stocks in private and government ownership that were carried over from the previous marketing year. Total demand is comprised of current food consumption, commercial exports, government export, private stocks, government stocks, and other demand factors (seed use etc.).

4.9 Farm Price

$$RCFPUS = F9[RCWPUS, TRC, Z_9] \tag{4.12}$$

where

RCWPUS = Rice, U.S. Wholesale Price

TRC = Transportation Cost Index, 1977=100

Z_9 = Dummy Variable

The equation is formulated such that the farm price is directly related to the wholesale price. A transportation cost index for grain is included to account for marketing margins.

4.10 U.S. Export Price

$$RCEPUS = F10[RCWPUS, MERM, RCEPTH, Z10] \tag{4.13}$$

where

RCWPUS = Rice, Wholesale Price

MERM = Exchange Rate, \$/foreign currency

RCEPTH = Rice, Export Price of Thailand

The U.S. export price is directly related to the wholesale price. Exchange rate (\$/foreign currency) also affects U.S. export price directly. We believe that the U.S. is the residual supplier in the world rice market while Thailand is the leader. As we discussed correlation between U.S. and Thailand export prices in the commercial export equation, Thailand export price leads to increase or decrease U.S. export price. After 1973 export boom U.S. export as well as world price are sharply increased. Therefore, dummy variables are used for 1973 to 1985 in the equation.

4.11 Thailand Export Price

$$
\begin{aligned}
RCEPTH \;&= F11 \;\; [RCFPTH, EXTAXTH, LAG(RCEPTH) \\
&\qquad WHTPWR/POPWR, INTPMI/INPOPMI] \quad (4.14)
\end{aligned}
$$

where

RCFPTH x = Thailand, Farm Price

EXTAXTH = Thailand, Export Tax

WHTPWR = Wheat, World Total Production

POPWR = World Population

INTPMI = Rice, Total Production of Major Importers

INPOPMI = Population of Major Importing Countries

This equation is formulated such that the export price of Thailand is directly related to the farm price. As mentioned before, to keep the low domestic price and to earn government revenue from rice exports, the Thailand government imposes an export tax on rice. The impact is hypothesized to be positive. There is a lag in the adjustment of Thailand export price to changes in world supply conditions. Therefore, a partial adjustment scheme is assumed for the equation. The Thailand export price is also hypothesized to be determined by world wheat production per capita (as a substitute crop) and total rice production per capita of major importing countries. The more rice production of major importers, the less export demand facing the duopolists, Thailand and the U.S..

4.12 Expected Net Returns

$$\begin{aligned} RCNRUS = {} & [(RCYHUS^{e} * Max(RCFPUS^{e}, RCLRUS)] \\ & - RCCOUS + Max[0, ((RCSUUS \\ & - Max(RCFPUS, RCLRUS)) * RCYHPA)] \end{aligned} \tag{4.15}$$

4.13 Expected Gross Returns

$$RCERUS(t) = [RCNRUS(t-1) + RCNRUS(t-2) + RCNRUS(t-3)]/3 \tag{4.16}$$

The expected gross returns equation is defined as a three-year moving average of expected net returns.

4.14 Deficiency Payments

$$RCDPUS = RCAPPA * RCYHPA * [RCSUUS - Max(RCFPUS^e, RCLRUS)] \tag{4.17}$$

where

RCAPPA = Rice, Farm Program Acreage

RCYHPA = Rice, Farm Program Yields

The deficiency payment is determined by farm program acreage times farm program yield times payment rate. The expected payment rate for the deficiency payment is modeled as the difference between the target price and an expected price. The expected price is either an expected farm price or the loan rate, whichever is higher.

5 ESTIMATION OF THE STRUCTURAL MODEL

This chapter is organized as follows. First, the estimation techniques appropriate for the specification of the systematic component of the structure are discussed. Secondly, the definitions and sources of the data used for the analysis are described. The estimated results of the model developed in the previous chapter are also presented. Finally, conclusions are presented in the last section.

5.1 Estimation Techniques

Consider the following equation system which is presented in matrix form:

$$AY = BX + U$$

where

Y = matrix of endogenous variables

X = matrix of predetermined variables

A = matrix of coefficients on endogenous variables

B = matrix of coefficients on predetermined variables

U = matrix of residuals

If matrix A can be expressed as a (block) triangular matrix, then the system of equations is called a (block-) recursive equation system. If matrix A can be expressed as a diagonal or block diagonal matrix, then the system is considered as a seemingly unrelated equation system. If matrix A cannot be expressed in either of the forms mentioned above, then the system is a simultaneous equation system.

In a recursive equation system, each of the endogenous variables can be determined sequentially, while a block-recursive equation system is a group of equations which can be broken up into groups or blocks of equations in such a way that groups of equations across blocks are recursive. A seemingly unrelated equation system is a specific type of recursive model which consists of a series of equations linked because the error terms across equations are correlated. A simultaneous equation system is a completely interdependent system in which any endogenous variable cannot be solved without simultaneously solving all equations.

If the disturbance terms across equations in a recursive system or a seemingly unrelated system are not correlated, ordinary least squares (OLS) would be a consistent and asymtotically efficient estimator applied in estimation. However, when the error terms are correlated across equations, the application of OLS would be inappropriate, and the efficiency of the parameter estimates could be improved using a more sophisticated estimation technique developed by Zellner. This technique is called seemingly unrelated regression (SUR), joint generalized least squares, or Zellner's method.

Zellner suggests that efficiency in estimation can be gained if one views the system of seemingly unrelated equations as a single large equation to be estimated. Estimation of this single system equation is accomplished efficiently through the use of generalized least squares estimation. SUR achieves an improvement in efficiency over OLS by taking into explicit account the fact that error terms across equations may not be zero.

In a simultaneous equation system, OLS estimation will generally yield biased and inconsistent parameter estimates. This is because the equations in the simultaneous system are interdependent such that some dependent variables from other equations appear as regressors in a certain equation. As a result, the endogenous variables which appear as regressors in a certain equation are correlated with the disturbance term of the equation; while OLS estimates will be consistent only if all the independent variables in a certain equation are uncorrelated with the disturbance term. Two-stage least squares (2SLS) and three-stage least squares (3SLS) are two popular estimating techniques applied to estimate a simultaneous equation system. 2SLS is a single-equation method, while 3SLS is a system method.

2SLS and 3SLS estimations can solve the problem of correlation of the disturbance term in a certain equation with the endogenous variables appearing as regressors in that equation and can thereby yield consistent estimates. However, if correlation exists among disturbances across equations, the 3SLS estimator is more efficient than the 2SLS estimator. This is because 3SLS involves the application of generalized least squares estimation to the system of equations, each of which has first been estimated using 2SLS, and takes into account cross-equation correlation. In the first stage of 3SLS, the reduced form of the equation system is estimated through OLS. The fitted values of the endogenous variables are then used to get 2SLS estimates of all the equations in the system. Once the 2SLS parameters have been calculated, the residuals of each equation are used to estimate the cross-equation variances and covariances. In the third stage, generalized least squares parameter estimates are obtained.

However, nonlinearities often enter economic models in various forms. In general, fundamental identities, as well as many other basic variables (e.g., relative prices), form ratios that render the model nonlinear. Moreover, a simultaneous equations system with autocorrelated error terms can lead to a nonlinear system (see Judge et al., 1982). Several attempts were made, with little or no success, to correct for the autocorrelation. Since the model was estimated by using a nonlinear estimation program, correction for the autocorrelation involved huge amounts of computer cost and also produced unsatisfactory results. In recognition of these problems, the original estimates are used for the analysis. The mathematical structure of the model presented in Chapter 4 is nonlinear. In view of the nonlinearity nature of the model, nonlinear three-stage least squares (N3SLS) was used for the final estimation of the model. The computer program used for the estimation is SYSNLIN of SAS/ETS (SAS, 1985).

N3SLS estimation procedure is a straightforward generalization of the linear three-stage least squares estimator. Gallant (1977) describes the simultaneous system consisting of M nonlinear equations as

$$q_\alpha(y_t, x_t, \theta^*_\alpha) = e_{\alpha t}, \quad \alpha = 1, 2, \cdots, M, \quad t = 1, 2, \cdots, n.$$

where y is an M by 1 vector of endogenous variables, x is a k by 1 vector of exogenous variables, θ^*_α is a P_α by 1 vector of unknown parameters contained in the compact parameter space H_α, and

$$e_{\alpha t} = (e_{1t}, e_{2t}, \cdots, e_{Mt})'$$

is the tM by 1 vector of residuals for the M endogenous variables stacked together. The N3SLS estimates the parameters by minimizing the generalized sum of squares of the residuals.

Gallant shows, if the following assumptions are satisfied and each equation in the model is identified, the N3SLS estimator is strongly consistent, asymptotically normally distributed, and more efficient than the nonlinear two-stage least squares estimator (N2SLS).

The assumptions are:

1) The moment matrix of the instrumental variables $(\frac{1}{n})Z^{'}Z$ converges to a positive definite matrix P; where Z is a k by 1 vector of instrumental variables.

2) The errors $\{e_{\alpha t}\}$ are independently and identically distributed each having mean zero and positive definite variance-covariance matrix Σ.

3) Each parameter space H_α is compact.

4) The true parameter value θ^*_α is contained in an open sphere O_α which is, in turn, contained in H_α.

5) Each function $q_\alpha(y, x, \theta_\alpha)$ and its first and second order derivatives with respect to θ_α are continuous in θ_α for fixed (y, x).

The identification rule is defined as:

The structural equation

$$q_\alpha(y_t, x_t, \theta_\alpha) = e_{\alpha t}$$

from a system satisfying the above assumption is said to be identified by the instruments Z_t if the only solution of the almost sure limit

$$\lim_{x \to \infty} (\frac{1}{n}) \sum_{t=1}^{n} Z_t' q_\alpha(y_t, x_t, \theta_\alpha) = 0$$

is $\theta_\alpha = \theta^*_\alpha$.

A rigorous treatment of the assumptions, identification, efficiency tests, and estimation of N3SLS procedure can be found in Gallant (1977).

Before the final estimates were obtained by using N3SLS, considerable time was spent in estimating the model by using ordinary least squares (OLS), two-stage least squares (2SLS), and nonlinear two-stage least squares (N2SLS). OLS was applied to each behavioral equation of the model to check the a priori expected signs of the variables in each equation, to test the goodness of fit of each equation, and to identify any misspecification of the variables.

Considering the simultaneous nature of the model, the next step was to use system method for the estimation. First, 2SLS was used to estimate the supply sector and the demand sector as two separate blocks to see how these two sectors perform individually. Then, both blocks were combined together as a single system and estimated by 2SLS. A comparison of 2SLS estimates with that of OLS estimates indicated substantial differences in the levels of estimated coefficients, implying that simultaneous equation bias in OLS estimates is significant for the hypothesized system.

Since the model is nonlinear in nature, N2SLS was also applied to the entire model. N2SLS assumes that endogenous variables of an equation are correlated with the disturbance term, but the disturbance terms across equation are not correlated, i.e., there is no contemporaneous correlation. Therefore, N2SLS ignores information that may be available concerning the error covariances. Also, the N2SLS estimator does not consider information concerning the endogenous variables that appear in the system but not in the i-th equation. Thus, the estimation of the model by N2SLS will yield consistent but biased estimates.

Table 5.1. Description, unit, and data source of variables

Variable	Description	Unit	Source
List of Endogenous Variables			
RCAPUS	Acreage planted in U.S.	1000 acres	USDA, Agricultural Statistics (various issues)
RCAHUS	Acreage harvested in U.S.	1000 acres	USDA, Agricultural Statistics (various issues)
RCYHUS	yields per acre in U.S.	lbs per acre	USDA, Agricultural Statistics (various issues)
RCTPUS	Total production in U.S.	1000 cwt.	USDA, Agricultural Statistics (various issues)
RCFOUS	Domestic food consumption in U.S.	1000 cwt.	USDA, Agricultural Statistics (various issues)
RCCEXUS	Commercial exports	1000 cwt.	USDA, Agricultural Statistics (various issues)
RCPSUS	Private ending stocks in U.S.	1000 cwt.	USDA, Agricultural Statistics (various issues)

Table 5.1 (Continued)

Variable	Description	Unit	Source
RCFPUS	Price received by farmers in U.S.	$ per cwt.	USDA, Rice Outlook and Situation (various issues)
RCWPUS	Wholesale price in U.S.	$ per cwt.	USDA, Rice Outlook and Situation (various issues)
RCEPUS	U.S. export price	$ per cwt.	USDA, Rice Outlook and Situation (various issues)
RCEPTH	Thailand export price	US $ per cwt.	USDA, Rice Outlook and Situation (various issues)
RCNRUS	Net returns for rice	$ per acre	Calculated based on season average price, yield, and variable cost
RCERUS	Expected gross returns for rice	$ per acre	Calculated based on net returns for rice (3-year moving average)
RCDPUS	U.S. Government deficiency payments for rice	million dollars	USDA, ASCS Commodity Fact Sheets for rice (various issues)

Table 5.1 (Continued)

Variable	Description	Unit	Source
List of exogenous Variables			
RIAALU9R	Land allotment/maximum acres planted	index, 1974=1	USDA, ASCS Commodity fact Sheets for rice (various issues)
RISK	Risk variable is specified as the square root of a weighted moving average of the squared deviation of actual net return from expected net returns (see Langley, 1983)	$ per acre	Calculated based on farmers' net returns per acre
RCADPA	Participant acreage diversion	acres	USDA, ASCS Commodity fact Sheets for rice (various issues)
RCCOUS	Rice, variable costs of production	$ per acre	USDA, Economic Indicators of the Farm Sector, Cost of Production (various issues)
DUM77	Dummy variable to represent the inauguration of the target price program in 1977	1977=1 other years=0	
DUM81	Dummy variable to represent the foreign demand shock in 1980	1981=1 other years=0	

Table 5.1 (Continued)

Variable	Description	Unit	Source
DUM83	Dummy variable to represent the PIK(payment-in-kind) program in 1983	1983=1 other years=0	
YEAR	Year		
DUM73	Dummy variable to reflect the production costs increase in 1973	1973=1 other years=0	
POPUS	U.S. total population	numbers	Council of Economic Advisers, Economic Report of the President, 1986
CPI	Consumer price index	index, 1972=100	U.S. Bureau of the Census, The Statistical Abstract of the U.S.
SHIFT73	Dummy variables to reflect	years$\geq$ 1973 = 1 other years=0	
WEGIN	Weighted income of major importing countries	million dollars	Calculated
RCGEXUS	Rice, U.S. Government exports	1000 cwt.	USDA, Agricultural Statistics (various issues)
RCSUUS	Rice, target price	$ per cwt.	USDA, Agricultural Statistics (various issues)

Table 5.1 (Continued)

Variable	Description	Unit	Source
SHIFT75	Dummy variable to reflect the export demand decrease since 1974	years$\geq$ 1975 = 1 other years=0	
DUM82	Dummy variable	1982=1 other years=0	
RCLRUS	Rice, loan rate	\$ per cwt.	USDA, Agricultural Statistics (various issues)
TRC	Railroad freight rates index for grain	index, 1967=100	USDA, Agricultural Statistics (various issues)
RCGSUS	Rice, U.S. Government ending stocks	1000 cwt.	USDA, Agricultural Statistics (various issues)
RCOTUS	Other domestic demand (i.e., seed, industry use etc.)	1000 cwt.	Calculated from the market-clearing identity
MERM	Effective exchange rate (IMF weight)	dollar per foreign currency, 1980=100, yearly average	Wharton Econometrics
EXTAXTH	Thailand export tax	\$ per cwt.	Quarterly Bulletin of Statistics, Thailand Government Publication (various issues)

Table 5.1 (Continued)

Variable	Description	Unit	Source
WHTPWR	Wheat, world total production	1000 MT	FAO, Production Yearbook (various issues)
POPWR	World total population	1000	FAO, Production Yearbook (various issues)
INTPMI	Rice, total production of major importing countries (i.e., Nigeria, Indonesia, Iran, Iraq, Korea, Saudi Arab)	1000 MT	FAO, Production Yearbook (various issues)
INPOPMI	Total population of major importing countries	1000	FAO, Production Yearbook (various issues)
RCAPPA	Rice, U.S. farm program acreage	acres	USDA, ASCS Commodity Fact Sheets for rice (various issues)
RCYHPA	Rice, U.S. farm program yields	lbs per acre	USDA, ASCS Commodity Fact Sheets for rice (various issues)
ADJUST	Adjustment term	million dollars	Calculated from deficiency payment identity

N3SLS takes explicit account of the covariance matrix including the contemporaneous correlation of error terms across equations. Hence, N3SLS is called the full information method, and N3SLS estimates are consistent and asymtotically more efficient than N2SLS estimates. Therefore, N3SLS was preferred over N2SLS for the final estimation of the model. Table 5.1 contains the variable names, descriptions, and data sources. The data period used for estimation is from 1960 to 1985.

5.2 Estimated Model

Because of the space limitation, models estimated by using OLS, 2SLS, and N2SLS are not reported. Only the final form of the model that is estimated by N3SLS is shown in Table 5.2. The model consists of 14 equations including 9 behavioral relationships and 5 identities. Each equation has the estimated coefficients[1]. Since the N3SLS estimates of the parameters of the model are consistent, asymtotically efficient, and have approximately a normal distribution, the t-test can be used for approximate statistical inference concerning the estimated coefficients of the equations. The t-values associated with each estimated coefficient are shown in the parentheses under each estimate. The elasticities for the related variables are given in brackets below the t-statistics. Coefficient of determination (R^2) and Durbin-Watson statistic (D-W) are presented as well, where appropriate. The results indicate all signs associated with the coefficients agree with a priori expectations and most of estimated parameters are significantly different from zero at

[1]As is usually the case in empirical analysis, some of the a priori specifications established in the theoretical model were abandoned; some variables were dropped and others added. The changes made in the theoretical model for the estimation are explained below.

the 1-percent level. The final results of the structural equation estimation could be used for the simulation experiments.

The supply section includes planted acreage, harvested acreage, yields per acre, and total production. Planted acreage response (equation 5.1) is hypothesized to be positively related to expected gross returns per acre from rice production, positively related to the land allotment, and negatively related to the risk. All parameters are statistically significant at the 1-percent level, while the expected gross returns is at the 5-percent level. The estimated elasticity of acreage planted with respect to expected gross returns is 0.11. That is, a 0.11-percent change in acreage is associated with a 1-percent change in expected gross returns in the same direction. Most of the previous studies use price (expectations), instead of expected returns concept, to see the acreage response. However, this elasticity is very close to the elasticities obtained by other studies (e.g., 0.125, Grant et al. (1984); 0.12, USDA, ERS (1984); 0.15, Langley (1983)). The estimated elasticity of acreage planted with respect to risk of returns is -0.06. That is, a 0.06-percent change in acreage is associated with a 1-percent change in risk of farm returns in the opposite direction. It is slightly higher than the elasticities obtained by Brosen et al. (1987), -0.026[2].

Acreage harvested (equation 5.2) is expressed as a linear function of acreage planted, and result indicates that almost all planted rice acreage is harvested.

The coefficients associated with the acreage diversion and trend have the hypothesized positive effect on yields (equation 5.3), and variable production costs have the expected negative impact. Attempts were made to include the deflated

[2]It is average of acreage response elasticities (of five major rice producing States) with respect to risk.

lagged farm price, weather index, and lagged yields but the coefficients' signs were incorrect and not statistically significant[3]. The recent study indicated no direct effect on yield by price changes, although the acreage changes in response to price changes did affect yields (see Grant et al., 1980). This study also found that yield was not appreciably affected by lagged deflated farm price. The estimated elasticity of yield with respect to the variable production costs is -0.14. That indicates that the variable production costs rather than lagged farm price influences yields per acre. Trend variable is involved and has a positive impact in the equation. It implies that development of new technology occurs over time.

Total demand is the sum of domestic food, exports (private and government), stocks (private and government), and other domestic uses (e.g., seed use, industrial use, etc.). Domestic food consumption, private exports, and private stocks are endogenously determined. Economic theory suggests that food demand for rice is influenced by the price of rice among others, and vice versa. Therefore,

$$RCFOUS/POPUS = WP01 + WP02 * (RCWPUS/CPI)$$

we can convert the food consumption per capita function to a market price function to get around the structural problem in a simultaneous equation system. The market wholesale price equation is solved from the food consumption equation and food consumption is solved from a market clearing condition. Therefore,

$$RCWPUS = WP01 * CPI + WP02 * ((RCFOUS * CPI)/POPUS)$$

[3]Since there was no single aggregate variable to represent the weather conditions across the country, the variable pasture condition was used for the weather index. However, it produced unsatisfactory results and, hence, was dropped from the equation.

Table 5.2: The estimated structural model

Supply Section

Acreage planted

$$\text{RCAPUS} = \underset{(19.63)}{2741.17} * \text{RIAALU9R} + \underset{\substack{(2.07)\\ [0.11]}}{1.40} * \text{RCERUS} - \underset{\substack{(-3.32)\\ [-0.06]}}{520.33} * \text{RISK}$$

$$- \underset{(-5.43)}{695.00} * \text{DUM77} + \underset{(6.34)}{879.67} * \text{DUM81} - \underset{(-7.74)}{891.63} * \text{DUM83}$$

$$R^2 = 0.92, \quad \text{DW} = 1.98 \tag{5.1}$$

Acreage harvested

$$\text{RCAHUS} = \underset{(0.59)}{33.76} + \underset{(42.36)}{0.99} * \text{RCAPUS}$$

$$R^2 = 0.98, \quad \text{DW} = 1.11 \tag{5.2}$$

Yields per acre

$$\text{RCYHUS} = - \underset{(-3.18)}{98220.92} + \underset{(0.79)}{0.05} * \text{RCADPA} - \underset{\substack{(-1.64)\\ [-0.14]}}{4.02} * \text{RCCOUS}$$

$$+ \underset{(3.31)}{52.37} * \text{YEAR} - \underset{(-2.27)}{324.32} * \text{DUM73}$$

$$+ \underset{(3.46)}{541.54} * \text{DUM85}$$

$$R^2 = 0.77, \quad \text{DW} = 1.62 \tag{5.3}$$

Total production

$$\text{RCTPUS} = \text{RCAHUS} * \text{RCYHUS} \tag{5.4}$$

Table 5.2 (Continued)

Demand Section

Domestic food consumption

$$\text{RCWPUS} = \underset{(5.52)}{(0.23} - \underset{\substack{(-4.10)\\ [-2.96]}}{0.001} * (\text{RCFOUS}/\text{POPUS}))* \text{CPI}$$

$$+ \underset{(3.18)}{8.11} * \text{SHIFT73}$$

$$R^2 = 0.40, \quad \text{DW} = 0.78 \qquad (5.5)$$

Commercial exports

$$\text{RCCEXUS} = \underset{(9.76)}{97569.5} - \underset{\substack{(-5.80)\\ [-2.17]}}{70053.2} * (\text{RCEPUS}/\text{RCEPTH})$$

$$+ \underset{\substack{(7.91)\\ [1.36]}}{571.1} * \text{WEGIN} - \underset{\substack{(-6.56)\\ [-0.6]}}{1.03} * \text{RCGEXUS}$$

$$R^2 = 0.90, \quad \text{DW} = 1.45 \qquad (5.6)$$

Private stocks

$$\text{RCPSUS} = -\underset{\substack{(-3.67)\\ [-0.40]}}{818.37} * \text{RCFPUS} + \underset{(3.86)}{0.10} * \text{RCTPUS} + \underset{\substack{(1.96)\\ [0.40]}}{832} *$$

$$\text{RCSUUS} + \underset{(5.37)}{9803.34} * \text{SHIFT75} + \underset{(7.10)}{15912.19} * \text{DUM82}$$

$$R^2 = 0.91, \quad \text{DW} = 2.43 \qquad (5.7)$$

Table 5.2 (Continued)

Price Linkages

Price received by farmers

$$\begin{aligned} \text{RCFPUS} = \;& 0.82 + 0.44 * \text{RCWPUS} - 0.005 * \text{TRC} \\ & (2.97)\ (26.0) \qquad\qquad (-2.64) \\ & \qquad\quad [0.95] \qquad\qquad [-0.07] \end{aligned}$$

$R^2 = 0.97$, DW = 2.02 (5.8)

U.S. export price

$$\begin{aligned} \text{RCEPUS} = \;& -9.18 + 0.55 * \text{RCWPUS} + 0.06 * \text{MERM} \\ & (-6.13)\ (6.87) \qquad\qquad (5.58) \\ & \qquad\quad [0.58] \\ & + 0.54 * \text{RCEPTH} + 2.45 * \text{SHIFT73} \\ & \quad (6.11) \qquad\qquad (6.93) \\ & \quad [0.75] \end{aligned}$$

$R^2 = 0.99$, DW = 2.03 (5.9)

Thailand export price

$$\begin{aligned} \text{RCEPTH} = \;& -7.50 + 0.93 * \text{EXTAXTH} + 0.13 * \text{LAG (RCEPTH)} \\ & (-2.01)\ (21.2) \qquad\qquad (2.95) \\ & \qquad\quad [0.69] \\ & + 0.12 * (\text{WHTPWR/POPWR}) - 33.22 \\ & \quad (4.93) \qquad\qquad\qquad (-0.67) \\ & \quad [0.95] \qquad\qquad\qquad [-0.15] \\ & * (\text{INTPMI/INPOPMI}) \end{aligned}$$

$R^2 = 0.98$, DW = 1.90 (5.10)

Table 5.2 (Continued)

Identities

Market - clearing identity

$$\begin{aligned} &\text{RCTPUS} + \text{LAG (RCPSUS)} - \text{LAG (RCGSUS)} \\ &\qquad = \text{RCFOUS} + \text{RCCEXUS} + \text{RCGEXUS} \\ &\qquad\quad + \text{RCPSUS} + \text{RCGSUS} + \text{RCOTUS} \end{aligned} \tag{5.11}$$

Expected net returns

$$\begin{aligned} \text{RCNRUS} = {} & \text{RCYHUS} * \text{Max (RCFPUS, RCLRUS)} \\ & - \text{RCCOUS} + \text{Max (0, ((RCSUUS - Max (RCFPUS,} \\ & \text{RCLRUS))} * \text{RCYHPA))} \end{aligned} \tag{5.12}$$

Expected gross returns

$$\begin{aligned} \text{RCERUS (t)} = {} & \text{[RCNRUS (t-1)} + \text{RCNRUS (t-2)} \\ & + \text{RCNRUS (t-3)]/3} \end{aligned} \tag{5.13}$$

Government deficiency payments

$$\begin{aligned} \text{RCDPUS} = {} & \text{RCAPPA} * \text{RCYHPA} * \text{Max (0, (RCSUUS -} \\ & \text{Max (RCFPUS, RCLRUS))} + \text{ADJUST} \end{aligned} \tag{5.14}$$

The estimated parameters are shown in Table 5.2 (equation 5.5). All parameters are statistically significant at the 1-percent level. The relationship between wholesale market price and food consumption agrees with a priori expectations. Prices of competing commodities (e.g., potatoes, corn, and wheat) were evaluated by Grant and Leath (1979). But, these competing products were not found to have any appreciable effect on food rice consumption. Also USDA researchers (USDA, ERS, 1984) suggested that changes in prices of potatoes, corn, and wheat products, as competing commodities, have been estimated to have almost no effect on rice demand. Attempts were made to regress the per capita rice consumption on deflated wholesale prices of rice and per capita real income, but the equation was less preferable than this equation. So, the deflated wholesale price of rice is the major variable affecting food rice consumption in this equation. The elasticity of the wholesale price with respect to per capita domestic food demand is -2.96[4]. Therefore, the elasticity of per capita domestic food demand with respect to the wholesale price is -0.34[5]. That is, a 0.34-percent change in per capita food demand for rice is associated with a 1-percent change in the opposite direction in the wholesale price. Several researchers have estimated the elasticity of total U.S. domestic demand with respect to farm price for various time periods as: -0.07 for 1975, Grant and Leath (1979); -0.04 for 1955-1957, Brandow (1961); -0.18 for 1982, Grant, Beach, and Lin

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[4]Since equation (5.5) is the price dependent function, it is price flexibility, not elasticity.

[5]When equation (5.5) was converted to quantity dependent function such as RCFOUS/POPUS = F [RCWPUS/CPI, SHIFT73], and estimated by OLS, the elasticity was -0.17 which is lower elasticity than that from equation (5.5). It implies that price flexibility is not the same as the reverse of demand elasticity (Houck, 1965).

(1984); -0.1, USDA-ERS (1984). All these estimates of demand elasticity are relatively low (inelastic), i.e., price changes have little impact on quantity demanded for food. All researchers above calculated elasticities for a specific time point, i.e., short-run elasticities. Note that the wholesale price and not retail price is used because of lack of data. So, the flexibility should be interpreted carefully. Also, since the retail price is not used, strictly speaking, equation (5.5) is not a consumer demand function.

Commercial exports demand (equation 5.6) was significantly influenced by the ratio of U.S.-Thailand export prices, weighted income growth of major importing countries (WEGIN), and the quantity exported under U.S. Government programs. The U.S. export price (RCEPUS) and the Thailand export price (RCEPTH) are highly correlated. However, each is affected by government programs in the respective countries. Government intervention variables are explained next in the export price equations. All coefficients are statistically significant at the 1-percent level. The relative export price and government exports have the expected negative impact on U.S. commercial exports, and the weighted income growth of importing countries has the hypothesized positive impact. The estimated elasticity of U.S. commercial exports with respect to the relative U.S. export price is -2.17, and the estimated elasticity of U.S. commercial exports with respect to the income growth of major importing countries is 1.36. The cross-elasticity of U.S. commercial exports to U.S. Government exports is -0.6. Results indicate that the export price elasticity of U.S. commercial exports is relatively higher (elastic) than the elasticities obtained by other studies (e.g., -0.68, Grant, Beach, and Lin (1984); -1.56, Grant and Moore (1970); -0.46, Grant, Holder, and Ericksen (1980)). However, this result is relatively lower (inelastic) than the export elasticity with respect to U.S. farm price at -4.45 obtained by Grant and Leath (1979). Moreover, the result is also lower than the elasticity for total exports (-3.16) obtained by Grant et al. (1984), which implies that the U.S. Government exports are more responsive to price changes than the commercial exports. The cross-elasticity of U.S. commercial exports to U.S. Government exports was -0.6. That is, the degree of substitution of P.L.480 rice for commercial sales is relatively low. Differentiated markets, quantity of product demand, and credit terms limit substitution between these markets.

Private stocks (equation 5.7) was significantly influenced by the farm price, total production, and government support price (target price). The estimated parameters have expected signs and also statistically significant at the 1-percent level. The estimated elasticities of private stocks with respect to the farm price and target price are -0.40 and 0.40 respectively. It indicates that a 1-percent change in the farm price is associated with 0.40-percent change in private stocks in the opposite direction, and a 1-percent change in target price is associated with 0.40-percent change in private stocks in the same direction. The farm price and target price affect private stocks with the same degree but with different direction. Attempts were made to include interest rates, expected total production in the next year, and lagged stocks but the coefficients signs were incorrect and not statistically significant.

Wholesale prices have the expected positive impact on farm price and transportation costs have the expected negative impact (equation 5.8). All parameters are statistically significant at the 1-percent level. The estimated elasticities of the wholesale price with the farm price and to transportation costs are 0.95 and -0.07 respectively. That indicates that a 1-percent change in the farm price is associated with approximately a 1-percent change in the wholesale price in the same direction. The transportation costs index accounting for marketing margins affected wholesale price movement in the same direction, but did not have significant influences because of very inelastic (i.e., -0.07).

U.S. export price (equation 5.9) is affected positively by wholesale price, effective exchange rates, and export price of Thailand. The estimated coefficients associated with all explanatory variables agree with a priori expectations, and are statistically significant at a 1-percent level. The estimated elasticities of the export price with respect to the wholesale price and Thailand export price are 0.58 and 0.75 respectively. That indicates that a 1-percent change in the wholesale price is associated with 0.58-percent change in U.S. export price in the same direction, and a 1-percent change in the Thailand export price is associated with 0.75-percent change in the U.S. export price in the same direction. It implies U.S. export price is more sensitive to a change in Thailand price than in domestic price. The U.S. export price is also positively affected by the weighted exchange rate (MERM).

The Thailand export tax was assumed to be directly related to the Thailand export price (equation 5.10). The Thailand export prices were also affected by world wheat production per capita, total rice production of major importing countries, and lagged Thailand export price for a partial adjustment scheme. Signs of all estimated coefficients agree with expectations and are statistically significant under a 5-percent level except the coefficient of total rice production of major importing countries. Elasticities of the Thailand export price with respect to the export tax, world wheat production per capita, and total rice production of major importing countries are 0.69, 0.95, and -0.15 respectively.

5.3 Conclusions

Planted acreage is mainly influenced by U.S. Government programs (i.e., land allotment and price support). Target price is modelled to affect rice farmers through the planted acreage equation and private stocks equation. Stable price also affects farmers to produce more rice. Acreage diversion scheme and variable costs of rice production are also important variables influencing domestic rice supply through the yields equation. However, elasticities of U.S. rice supply with respect to these important explanatory variables are relatively lower than elasticities in the demand side. It indicates U.S. rice supply is relatively stable compared to domestic demand or foreign demand.

An area of concern deals with the elasticity of demand for U.S. food (-0.34), which is relatively higher than that from the previous studies. The high food demand elasticity may be due to a shift in ethnic populations since the seventies rather than in whole U.S. populations. Moreover, because we converted the food consumption per capita function to the wholesale price function to get around the structural problem for estimating a simultaneous equation system, calculated demand elasticity was inverse of the price flexibility. However, in general, elasticity is not inverse of the flexibility unless there is no cross price effects.

Another area of concern deals with the high elasticity of demand for U.S. commercial exports (-2.17). But this elasticity is lower than that for world total exports (-3.16) obtained by Grant et al. (1984). Most of the previous studies did not care about endogenizing Thailand export price and hence elasticities estimated by them may be biased.

Finally, cross-price elasticity of U.S. export price with respect to Thailand export price is very reasonable (0.75), and elasticities of Thailand export price with respect to Thailand export tax and world demand shifts are also reasonable. Hence, the demand shocks from outside can be analyzed well through the Thailand export price equation. Another important point to note is that all the estimated coefficients of the variables involved in the model have the right signs and most of them are statistically significant at a 1-percent level.

6 MODEL VALIDATION

In this chapter, the overall ability of the model to replicate the observed values of the endogenous variables and the stability of the model will be tested by using various test criteria.

The performance of the model can be evaluated by its ability to reproduce the actual data in an ex-post simulation, the validity of its estimates, and its stability. Since the model is to be used for multiplier and dynamic simulation analysis, a rigorous validation procedure is undertaken.

After the model is estimated, the equations are examined, on a one-by-one basis, regarding the theoretical reasonableness as well as the statistical significance of each equation's coefficients and overall fit. Then a historical simulation over the estimated period is performed, given the historical series for the exogenous variables and the initial values for the endogenous variables. How closely each endogenous variable tracks its corresponding historical data series is then examined to evaluate the performance of the model.

The simulation procedure is dynamic in the sense that solved values are used for lagged values of endogenous variables rather than the actual values for those variables. A dynamic simulation seems preferable since it allows the researcher to study the evolutionary charactor of the model over time. As the model is nonlinear, a nonlinear simulation procedure, SIMNLIN from SAS/ETS(SAS, 1985), is used to solve the model. The Gauss-Seidel solution method is used for the validation run and all future simulation.

Before presenting the simulation results, several goodness of fit criteria that are often used in evaluating individual equations within a model are discussed. Though none is perfect, the criteria can increase subjective confidence in the model and help evaluate changes in the model. The measures used to assist the evaluation for each equation are following[1].

6.1 Test Criteria

6.1.1 Root Mean Square Simulation Error (RMSE)

The measure that is most often used is called the RMSE (root-mean-square simulation error). The RMSE for the variable Y_t is defined as

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)^2} \tag{6.1}$$

where

Y_t^s = simulated value of Y_t

Y_t^a = actual value

T = number of periods in the simulation

In simple terms, the RMSE is a measure of the deviation of the simulated variable from its actual time path. Of course, the magnitude of this error can be evaluated only by comparing it with the average size of the variable in question.

[1]See Pindyck and Rubinfeld (1981) for further details on evaluating the simulation model.

6.1.2 Root Mean Square Percent Error (RMSPE)

This is also a measure of the deviation of the simulated variable from its actual time path but in percentage terms. Thus, RMSPE is defined as

$$RMSPE = \sqrt{\frac{1}{t}\sum_{t=1}^{T}\left(\frac{Y_t^s - Y_t^a}{Y_t^a}\right)^2} \tag{6.2}$$

6.1.3 Mean (Simulation) Error and Mean Percent Error

Other measures are the mean simulation error (ME), defined as

$$ME = \frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a) \tag{6.3}$$

and the mean percent error (MPE), defined as

$$MPE = \frac{1}{T}\sum_{t=1}^{T}\frac{Y_t^s - Y_t^a}{Y_t^a} \tag{6.4}$$

However, the problem with mean (percent) errors is that they may be close to 0 if large positive errors cancel out large negative errors. Therefore, the RMSE (or RMSPE) would be better measures of the simulation performance[2].

6.1.4 Turning Point Method

Low root-mean-square simulation errors are only one of the desirable measures of simulation fit. Another important criterion is how well the model simulates turning points in the historical data. Even if a model could fit well with smaller

[2]Mean absolute errors (and mean absolute percent errors) can also be calculated to avoid the problem of positive and negative errors canceling. However, RMSE(RMSPE) are used more often in practice since they penalize large individual errors more heavily.

RMSE, it is possible not to be able to predict or explain the fluctuation in the endogenous variables because of failing to predict turning points in the system or only predicting them with a lag. Therefore, the ability of a simulation model to duplicate turning points or rapid changes in the actual data is an important criterion for model evaluation

6.1.5 Theil's Inequality Coefficient (U)

A useful simulation statistic related to the RMSE and applied to the evaluation of historical simulations is Theil's inequality coefficient, defined as

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s)^2} \; + \; \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^a)^2}} \tag{6.5}$$

Note that the numerator of U is just the RMSE, but the scaling of the denominator is such that U will always fall between 0 and 1. If U=0, $Y_t^s = Y_t^a$ for all t and there is a perfect fit. If U=1, on the other hand, the predictive performance of the model is as bad as it possibly could be. When U=1, simulated values are always 0 when actual values are nonzero, or nonzero predictions have been made when actual values are zero and hence easy to predict, or simulated values are positive (negative) when actual values are negative (positive).

The Theil's inequality coefficient can be decomposed into three different components: U^M, U^S, and U^C. These proportions can be derived with little algebra in that

$$\frac{1}{T}\sum(Y_t^s - Y_t^a)^2 = (\bar{Y}^s - \bar{Y}^a)^2 + (\sigma_s - \sigma_a)^2 + 2(1-\rho)\sigma_s\sigma_a \tag{6.6}$$

where $\bar{Y}^s$, $\bar{Y}^a$, σ_s, and σ_a are the means and standard deviations of the series

Y_t^s and Y_t^a, respectively, and ρ is their correlation coefficient[3]. We can define the proportions of inequality as

$$U^M = \frac{(\bar{Y}^s - \bar{Y}^a)^2}{(1/T)\sum(Y_t^s - Y_t^a)^2} \tag{6.7}$$

$$U^S = \frac{(\sigma_s - \sigma_a)^2}{(1/T)\sum(Y_t^s - Y_t^a)^2} \tag{6.8}$$

$$U^C = \frac{2(1-\rho)\sigma_s\sigma_a}{(1/T)\sum(Y_t^s - Y_t^a)^2} \tag{6.9}$$

The proportions, U^M, U^S, and U^C are called the bias, the variance, and the covariance proportions, respectively, and they are useful as a means of breaking the simulation error down into its characteristic sources[4].

The bias proportion U^M is an indication of systematic error, since it measures the extent to which the average values of the simulated and actual series deviate from each other. For better prediction of the actual values, U^M should be close to zero. The variance proportion U^S indicates the ability of the model to replicate the degree of variability in the variable of interest. If U^S is large, it means that the actual series has fluctuated considerably while the simulated series shows little fluctuation, or vice versa. Finally, the covariance proportion measures what we might call unsystematic error; i.e., it represents the remaining error after deviations from average values and average variabilities have been accounted for. The perfect correlation of simulation values with actual values would imply the ideal distribution of inequality over the three sources as $U^M = U^S = 0$, and $U^C = 1$.

[3]That is, $\rho = (1/\sigma_s\sigma_a T)\sum(Y_t^s - \bar{Y}^s)(Y_t^a - \bar{Y}^a)$ (see Pindyck and Rubinfeld, 1981).
[4]From equation (6.6), $U^M + U^S + U^C = 1$.

6.2 Results of the Model Validation

The overall goodness of fit of the model is evaluated by the RMSE, RMSPE, Theil's inequality coefficient, and the ability of the model to predict the turning points. In this study, the model performs very well in tracking the observed values. Table 6.1 presents RMSE and RMSPE for all endogenous variables. Table 6.2 reports Theil's forecast statistics for these endogenous variables. The observed and predicted values for all endogenous variables are plotted in Figures 6.1 - 6.14.

Most of the endogenous variables had very low RMSPE, except for government deficiency payments, which would imply the simulated values track the actual values fairly closely. The high RMSPE for government deficiency payments variable is due to its relatively big fluctuations compared to their small (most even zero) values over the period studied.

Theil's forecast error measures complement the RMSE and RMSPE in explaining the predictability of a simulation model. The value of bias for all the endogenous variables are close to zero except for the expected gross returns variable. The value of the regression for the expected gross returns variable is quiet small, which resulted in a better prediction of the actual value (i.e., see Figure 6.13). As can be seen from Table 6.2, the value of Theil's inequality coefficient for all the endogenous variables are close to zero, implying the model has performed remarkably well in simulating the actual values.

Table 6.1: Root mean square error (RMSE) and root mean square percentage error (RMSPE) from the dynamic simulation

Variable	RMSE	RMSPE
Acreage planted (RCAPUS)	178.19	0.060
Acreage harvested (RCAHUS)	182.84	0.065
Yields per acre (RCYHUS)	145.68	0.032
Total production (RCTPUS)	7360.54	0.057
Domestic food consumption (RCFOUS)	6674.68	0.242
Commercial exports (RCCEXUS)	6616.19	0.180
Private stocks (RCPSUS)	3638.76	0.214
Farm price (RCFPUS)	0.96	0.106
Wholesale price (RCWPUS)	1.88	0.091
U.S. export price (RCEPUS)	1.22	0.076
Thailand export price (RCEPTH)	0.79	0.079
Expected net returns (RCNRUS)	35.23	0.141
Expected gross returns (RCERUS)	14.97	0.065
Government deficiency payments (RCDPUS)	33.87	100805.00

Table 6.2. Theil's forecast error measures from the dynamic simulation

Variable	Bias U^M	MSE decomposition: Regression U^S	MSE decomposition: Disturbance U^C	Accuracy U
Acreage planted (RCAPUS)	0.010	0.061	0.928	0.0348
Acreage harvested (RCAHUS)	0.010	0.039	0.952	0.0357
Yields per acre (RCYHUS)	0.005	0.015	0.980	0.0158
Total production (RCTPUS)	0.021	0.076	0.902	0.0310
Domestic food consumption (RCFOUS)	0.035	0.252	0.713	0.1067
Commercial exports (RCCEXUS)	0.008	0.071	0.921	0.0661
Private stocks (RCPSUS)	0.002	0.066	0.932	0.0893
Farm price (RCFPUS)	0.015	0.158	0.828	0.0574
Wholesale price (RCWPUS)	0.014	0.123	0.863	0.0513
U.S. export price (RCEPUS)	0.006	0.198	0.796	0.0338
Thailand export price (RCEPTH)	0.017	0.054	0.928	0.0267

Table 6.2 (Continued)

Variable	MSE decomposition			
	Bias U^M	Regression U^S	Disturbance U^C	Accuracy U
Expected net returns (RCNRUS)	0.034	0.039	0.927	0.0700
Expected gross returns (RCERUS)	0.338	0.118	0.543	0.0331
Government deficiency payments (RCDPUS)	0.041	0.188	0.772	0.1214

The ability of the model to duplicate turning points or rapid changes in the actual data of all endogenous variables will be examined by looking at Figures 6.1 to 6.14. We observe that the simulated series do seem to reproduce the general long-run behavior of the actual series, although a few short-run fluctuations in the actual series are not reproduced. It is also clear that the endogenous variables in the demand sector, in general, simulate the actual series better than the endogenous variables in the supply sector. This may be due to the fact that agricultural supply is subject to higher risk and uncertainty than the demand sector. However, the demand sector of the model is not independent of the supply sector since factors affecting supply also affect the demand sector in this simultaneous equation system. Moreover, as mentioned in previous chapters, some factors from world markets are uncertain and unexpectable. As a result, most variables tend to have equal short-run fluctuations. The missed turning point errors ranged from a low of 2 on RCAHUS to a high of 7 on RCFOUS.

For the acreage planted, the simulated values are closer to the actual values over the entire period. By far the biggest difference between the actual and simulated values of planted acreage is in 1980. This might be due to the larger price fluctuation because of unexpected foreign import demand in this period. Acreage harvested relatively performs better than acreage planted. Yields and total production perform well barring minor turning point errors. A relatively poor job seems to have been done in tracking the domestic food demand; it might be due to the identity equation. The variable used for the market-clearing identity absorbs all disturbance errors in the system. The commercial exports and private ending stocks perform extremely well. Farm price has three turning errors in 1982, 1984, and 1985; however, the sharp increases in U.S. farm price in 1973 and 1980 are predicted very well. Both wholesale and U.S. export price have perfect fit ,except for the small difference since 1981. Thailand export price has no turning point errors. Other endogenous variables, such as expected net returns, expected gross returns, and government deficiency payments, have performed remarkably well. In general, results suggest that some headway has been made in predicting the actual values by the construction of the econometric model.

The stability of the model is analyzed by calculating the characteristic roots from the characteristic equation that is derived from the model. If the model is large and nonlinear, calculating the characteristic roots becomes a cumbersome task. In such cases, the best one can do to determine whether or not the model is stable in the long term is to simulate the model over a long period of time (see Pindyck and Rubinfeld, 1981). Hence, a good fit of the model would imply the model is stable. Thus, the above dynamic historical simulation of the model over the entire period indicates the model is stable.

Other ways of testing the model stability is to perform a series of simulations, over different periods of time and using different time paths for the exogenous variables in the model. For the present case, the Thailand export tax in 1973 is exogenously decreased by 10-percent to test the stability of the model. If the changes in the endogenous variables to this shock decline as time passes, and the simulation values move back to base values, then the model is stable. The faster the adjustment back toward the base simulation values, the more stable the model.

Table 6.3: Dynamic impacts of a decrease in the Thailand export tax by ten percent in 1973

Variable	Year	1973	1974	1975	1976	1977
Acreage planted	Base	2131.4	2521.1	2783.0	2848.0	2209.4
(1000 acres)	Change	0.87	-8.65	-11.16	-9.94	-0.01
	% change	0.04	-0.34	-0.40	-0.35	-0.00
Acreage harvested	Base	2136.9	2521.5	2779.9	2844.1	2213.9
(1000 acres)	Change	6.45	-8.11	-14.05	-13.70	4.53
	% change	0.30	-0.32	-0.50	-0.48	0.21
Yields per acre	Base	4223.6	4560.1	4499.9	4572.4	4624.8
(lbs/acre)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
Total production	Base	90267	114974	125090	130052	102389
(1000 cwt.)	Change	36.41	-389.40	-495.68	-448.60	-0.88
	% change	0.04	-0.34	-0.39	-0.34	-0.00
Domestic food	Base	10577.2	25144.1	26511.1	39154.8	31517.6
consumption	Change	2030.18	254.96	-82.93	-143.57	62.25
(1000 cwt.)	% change	19.19	1.01	-0.31	-0.36	0.20
Commercial exports	Base	53227.1	47996.2	33394.7	52794.0	53060.6
(1000 cwt.)	Change	-1875.7	-274.4	-299.0	-279.0	102.5
	% change	-3.52	-0.57	-0.89	-0.52	0.19
Private stocks	Base	3575.8	9406.5	20861.6	23748.0	19032.3
(1000 cwt.)	Change	378.29	17.73	-68.47	-45.40	22.24
	% change	10.58	0.19	-0.33	-0.19	0.11
Farm price	Base	12.35	9.60	9.76	6.54	9.07
(dollars/cwt.)	Change	-0.46	-0.06	0.02	0.04	-0.01
	% change	-3.72	-0.66	0.23	0.61	-0.20
Wholesale price	Base	26.71	20.67	21.16	13.98	19.76
(dollars/cwt.)	Change	-1.04	-0.14	0.05	0.09	-0.04
	% change	-3.88	-0.69	0.24	0.65	-0.21

1978	1979	1980	1981	1982	1983	1984	1985
2776.6	2855.2	2857.5	3855.7	2991.7	2186.7	3085.5	2199.4
0.94	0.32	-0.55	-2.63	-2.49	-2.49	-0.03	-0.00
0.03	0.01	-0.01	-0.06	-0.08	-0.11	-0.00	-0.00
2773.6	2851.2	2853.5	3838.5	2985.9	2191.6	3078.4	2204.1
-2.02	-3.67	-4.55	-19.80	-8.24	2.40	-7.06	4.68
-0.07	-0.12	-0.16	-0.51	-0.28	0.11	-0.23	0.21
4669.2	4713.5	4641.3	4601.3	4764.3	4728.9	4773.7	5384.2
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
129501	134392	132433	176628	142266	103562	147828	118765
43.09	14.92	-24.98	-119.29	-116.86	-16.03	-1.59	-0.32
0.03	0.01	-0.01	-0.06	-0.08	-0.01	-0.00	-0.00
33416.2	35363.2	30802.0	40313.7	39235.1	39208.9	41904.1	44103.9
20.78	7.81	292.62	88.79	-17.11	-11.76	4.19	-21.02
0.06	0.02	0.95	0.22	-0.04	-0.03	0.01	-0.04
65660.4	74369.8	79074.2	85089.9	54738.9	41220.7	28964.2	27406.8
35.0	13.0	456.7	205.3	-53.5	-4.7	-1.4	-0.1
0.05	0.01	0.58	0.24	-0.09	-0.01	-0.00	-0.00
21967.5	22913.7	21065.6	28964.7	41001.1	21636.9	27009.9	24962.5
9.52	3.67	191.66	28.81	-17.49	-4.58	6.02	-8.66
0.04	0.01	0.90	0.09	-0.04	-0.02	0.02	-0.03
8.94	8.88	11.36	8.08	8.97	9.23	8.34	7.45
-0.01	-0.00	-0.11	-0.04	0.00	0.00	-0.00	0.00
-0.07	-0.03	-1.00	-0.47	0.00	0.00	-0.00	0.00
19.53	19.60	25.51	18.39	20.56	21.16	19.25	17.33
-0.01	-0.01	-0.25	-0.08	0.02	0.09	-0.05	0.21
-0.07	-0.03	-1.01	-0.46	0.08	0.42	-0.28	1.24

Table 6.3 (Continued)

Variable	Year	1973	1974	1975	1976	1977
U.S. export price	Base	28.96	22.76	19.31	15.38	19.90
(dollars/cwt.)	Change	-1.75	-0.23	0.01	0.05	-0.02
	% change	-6.04	-1.03	0.04	0.31	-0.11
Thailand export	BASE	26.43	20.81	14.02	13.44	15.48
price (dollars/cwt.)	Change	-2.19	-0.29	-0.04	-0.01	-0.00
	% change	-8.28	-1.38	-0.27	-0.03	-0.00
Expected net	Base	381.5	287.9	261.4	126.1	246.6
returns	Change	-19.42	-2.91	1.01	1.85	-0.86
(dollars/acre)	% change	-5.09	-1.01	0.38	1.47	-0.34
Expected gross	Base	153.8	245.1	300.4	310.3	225.1
returns	Change	0.62	-6.19	-7.98	-7.11	-0.01
(dollars/acre)	% change	0.41	-2.52	-2.66	-2.29	-0.01
Government deficiency	Base	0.00	0.00	0.00	0.00	0.00
payments	Change	0.00	0.00	0.00	0.00	0.00
(million dollars)	% change	0.00	0.00	0.00	0.00	0.00

1978	1979	1980	1981	1982	1983	1984	1985
19.35	20.37	25.31	19.29	19.43	19.22	18.81	17.57
-0.01	-0.00	-0.14	-0.05	0.01	0.00	-0.00	0.00
-0.04	-0.01	-0.56	-0.24	0.04	0.00	-0.00	0.00
16.33	18.39	21.49	16.14	12.60	11.79	10.65	9.52
-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
242.3	249.4	319.2	260.1	286.1	294.6	320.1	347.6
-0.31	-0.00	-5.32	-0.00	-0.00	-0.06	0.05	0.01
-0.12	-0.00	-1.67	-0.00	-0.00	-0.02	0.01	0.00
211.4	205.0	246.1	270.3	276.2	288.5	280.2	300.3
0.66	0.22	-0.38	-1.87	-1.77	-1.77	-0.02	0.00
0.31	0.11	-0.15	-0.69	-0.64	-0.61	-0.00	0.00
27.44	13.90	0.00	102.18	171.26	171.89	343.46	374.00
0.00	0.23	0.00	3.14	-0.89	-3.65	2.91	0.00
0.00	1.63	0.00	3.07	-0.52	-2.13	0.84	0.00

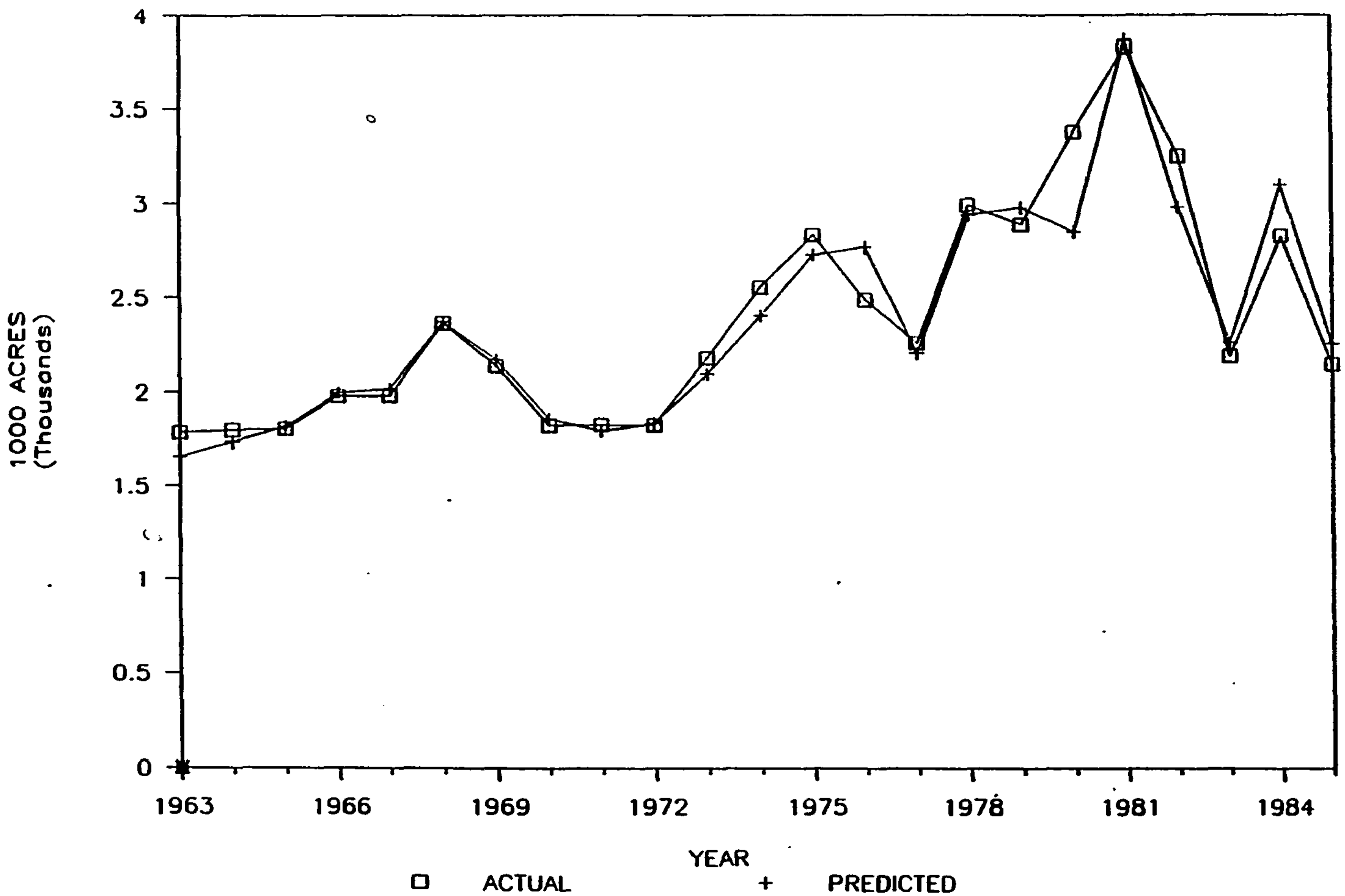

Figure 6.1: Predicted versus actual values of acreage planted

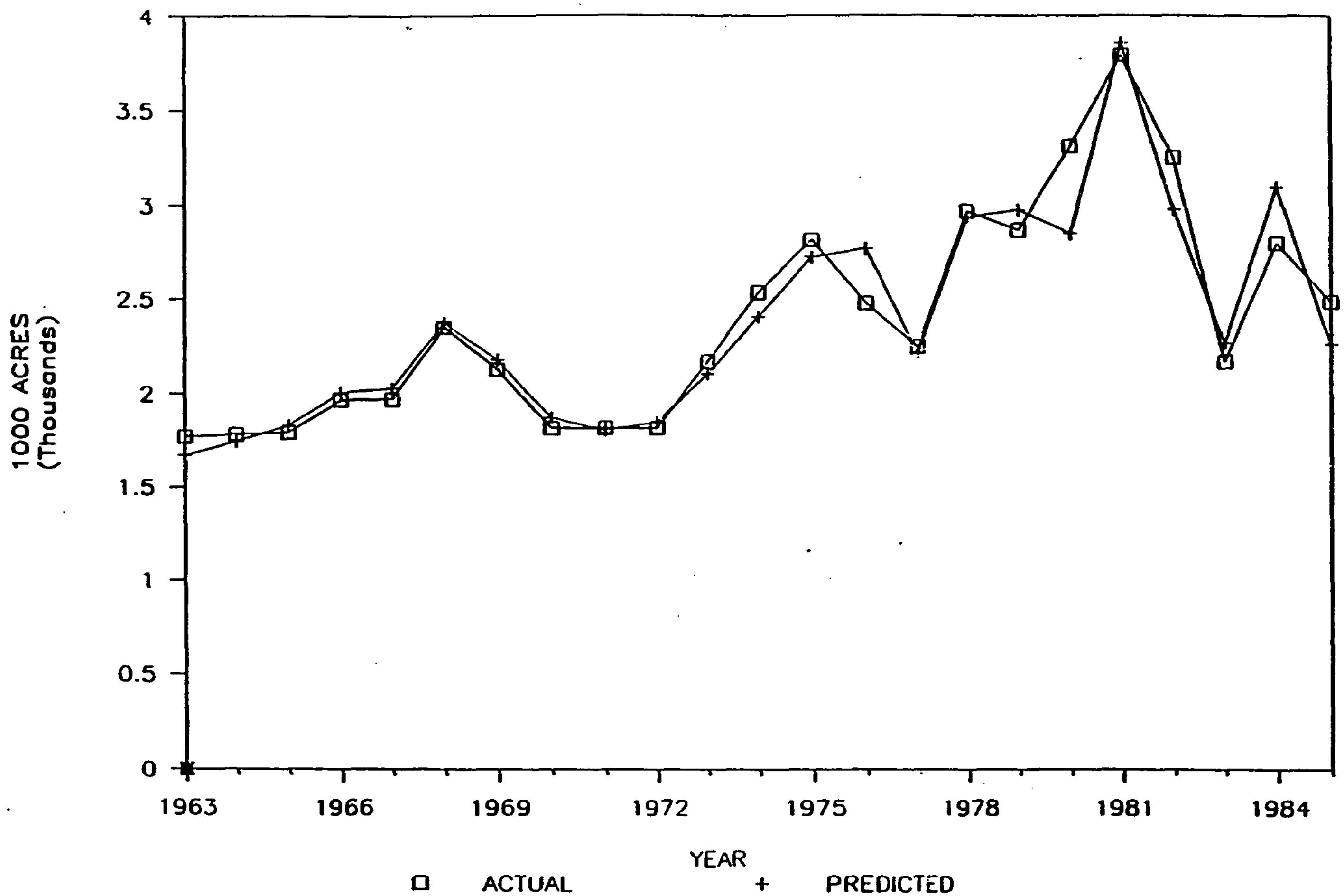

Figure 6.2: Predicted versus actual values of acreage harvested

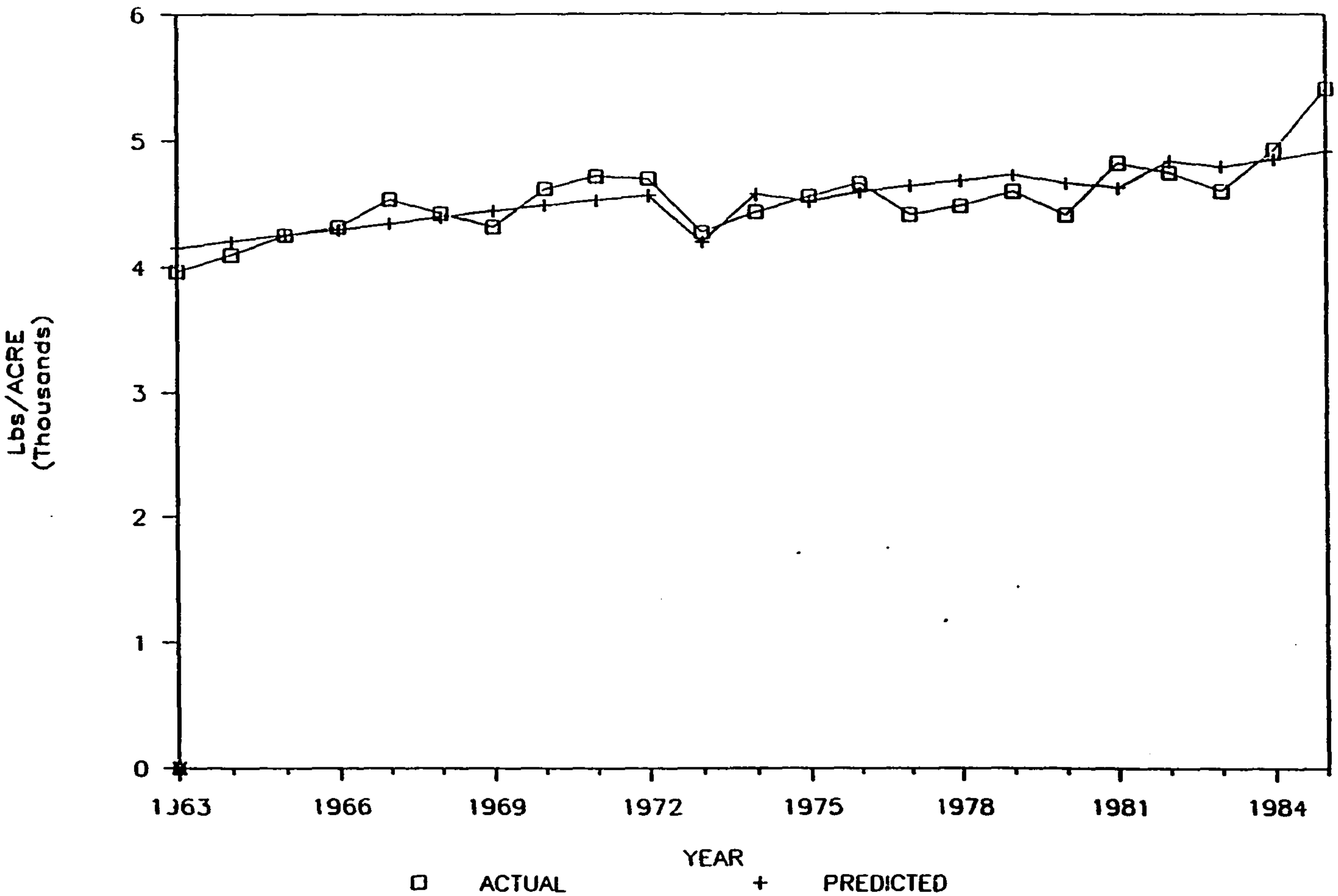

Figure 6.3: Predicted versus actual values of yields

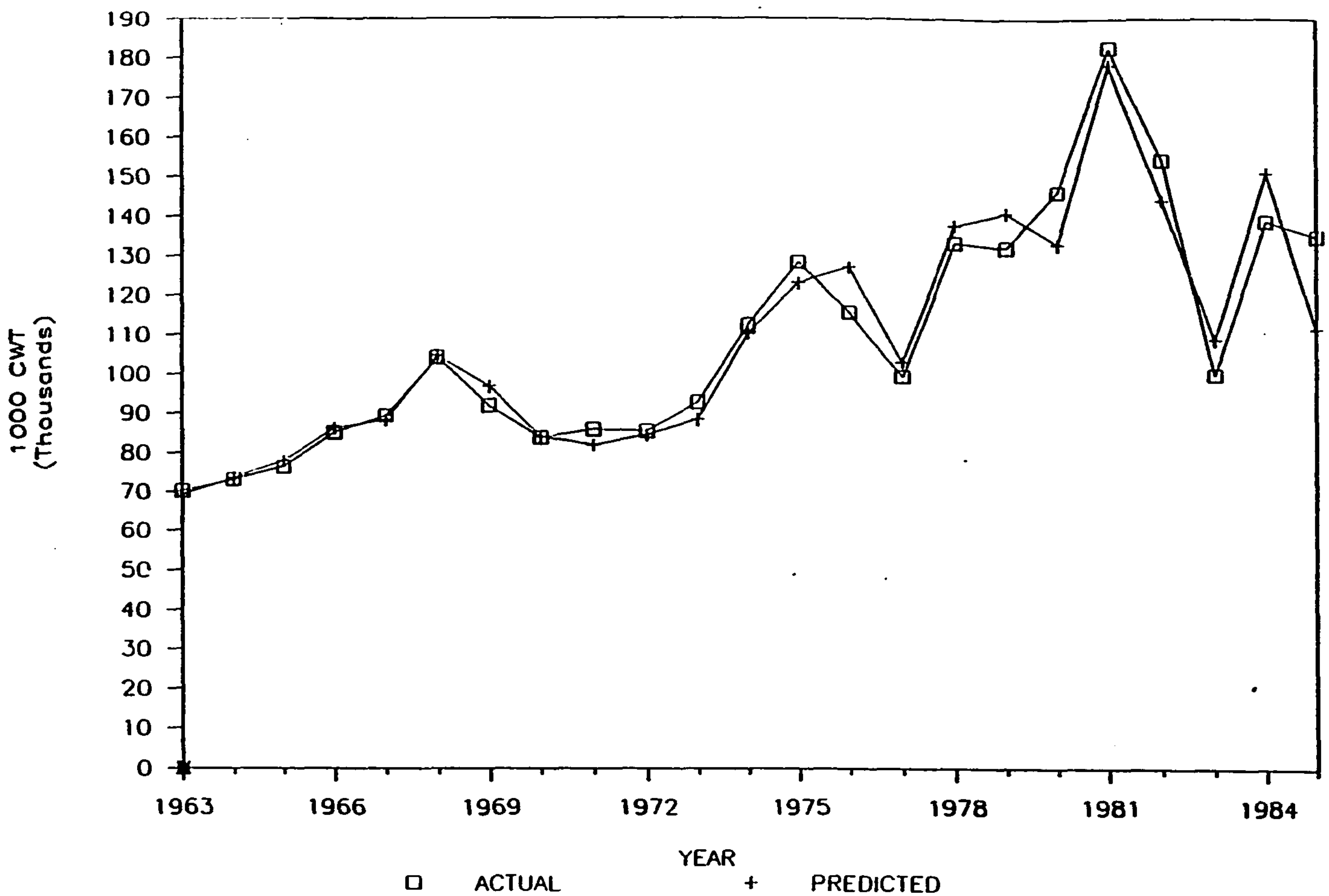

Figure 6.4: Predicted versus actual values of total production

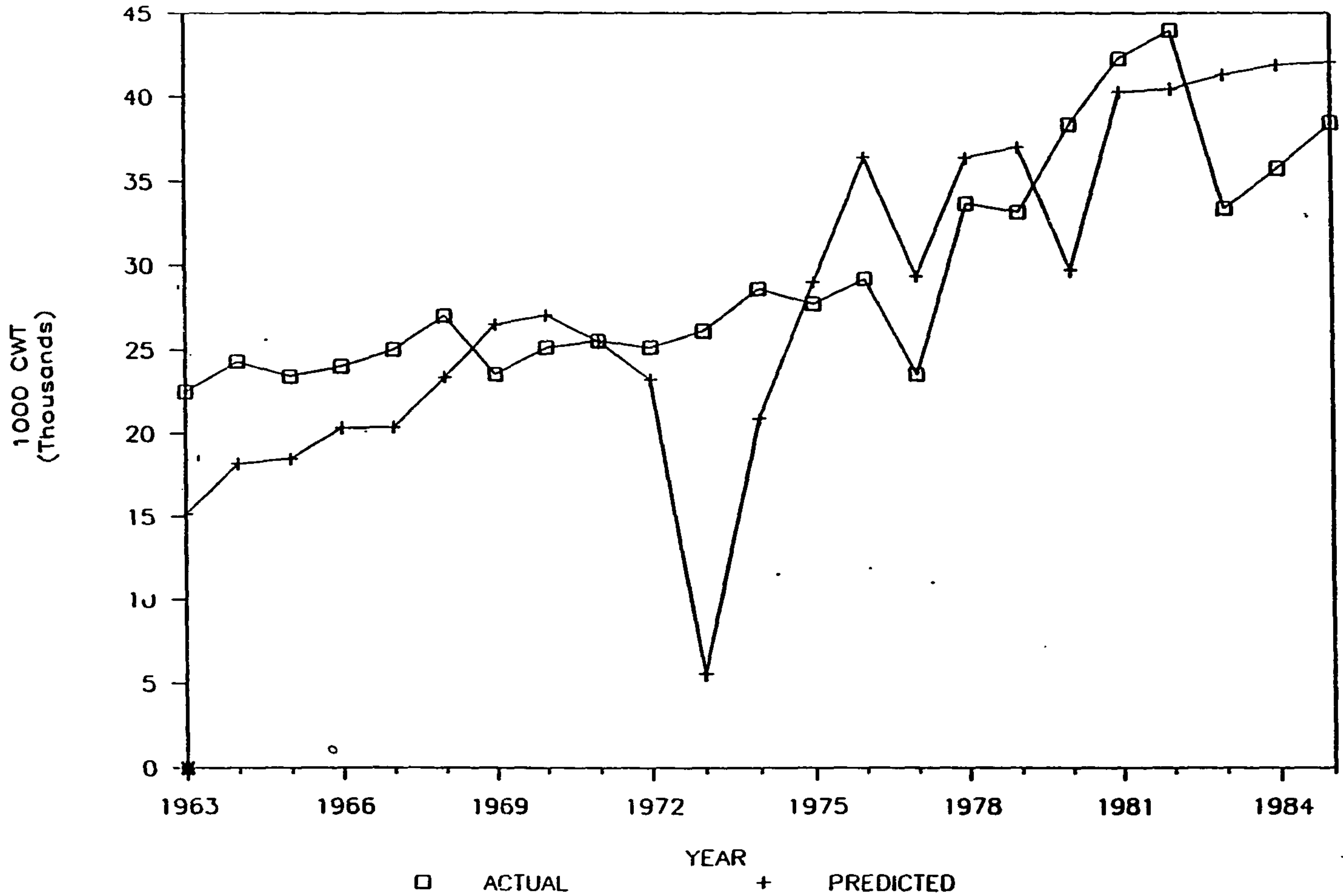

Figure 6.5: Predicted versus actual values of domestic food consumption

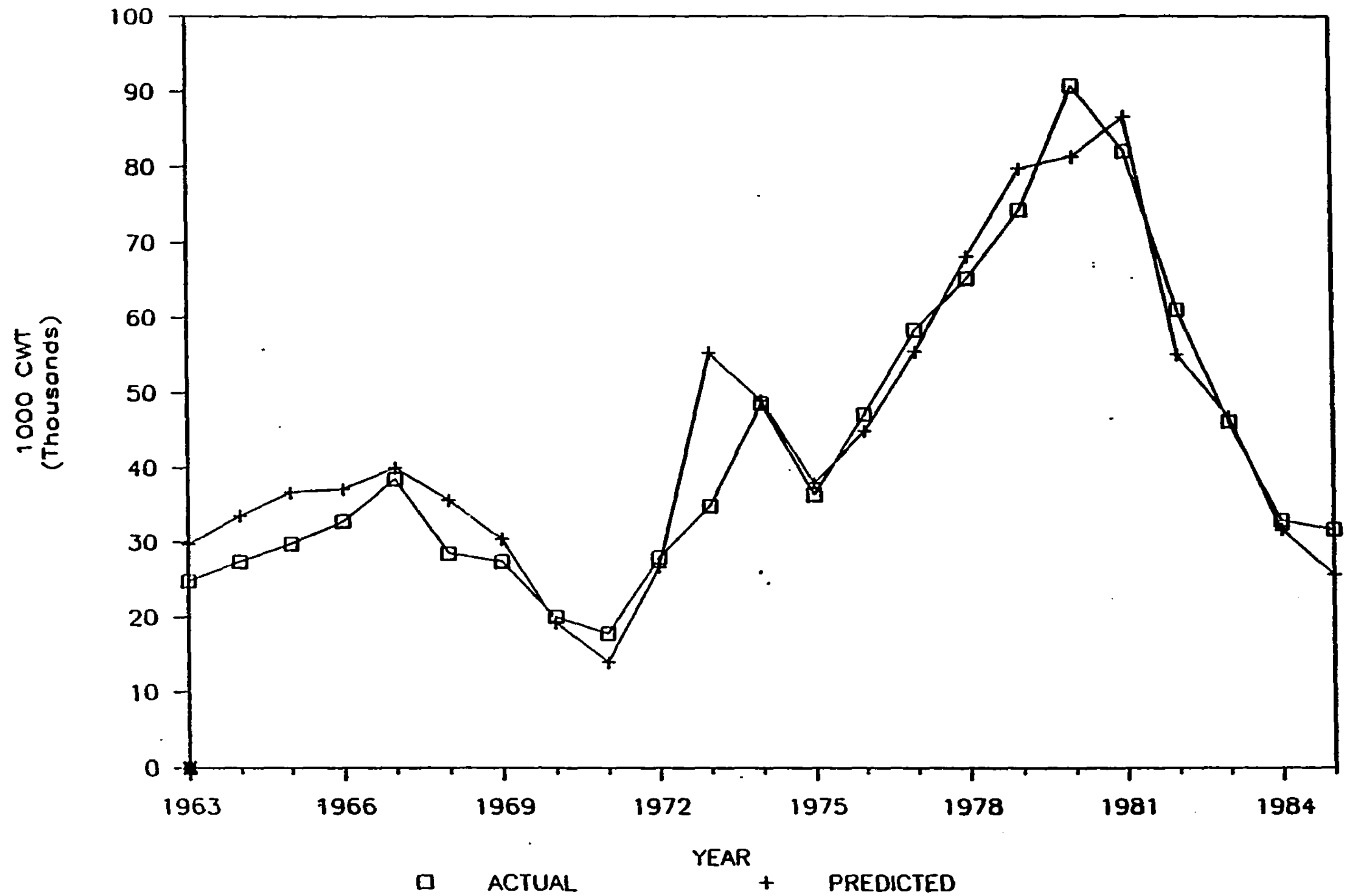

Figure 6.6: Predicted versus actual values of commercial exports

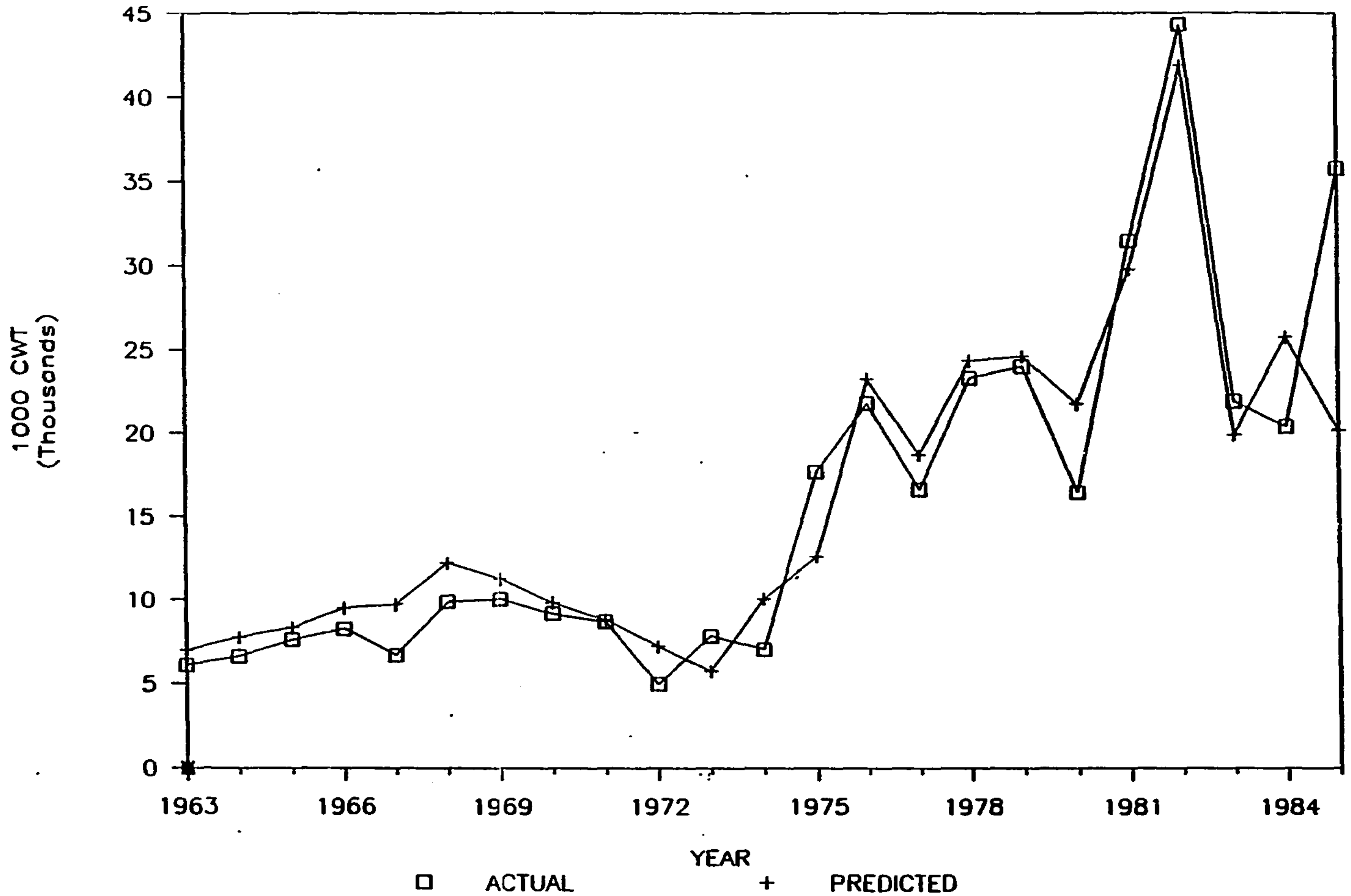

Figure 6.7: Predicted versus actual values of private ending stocks

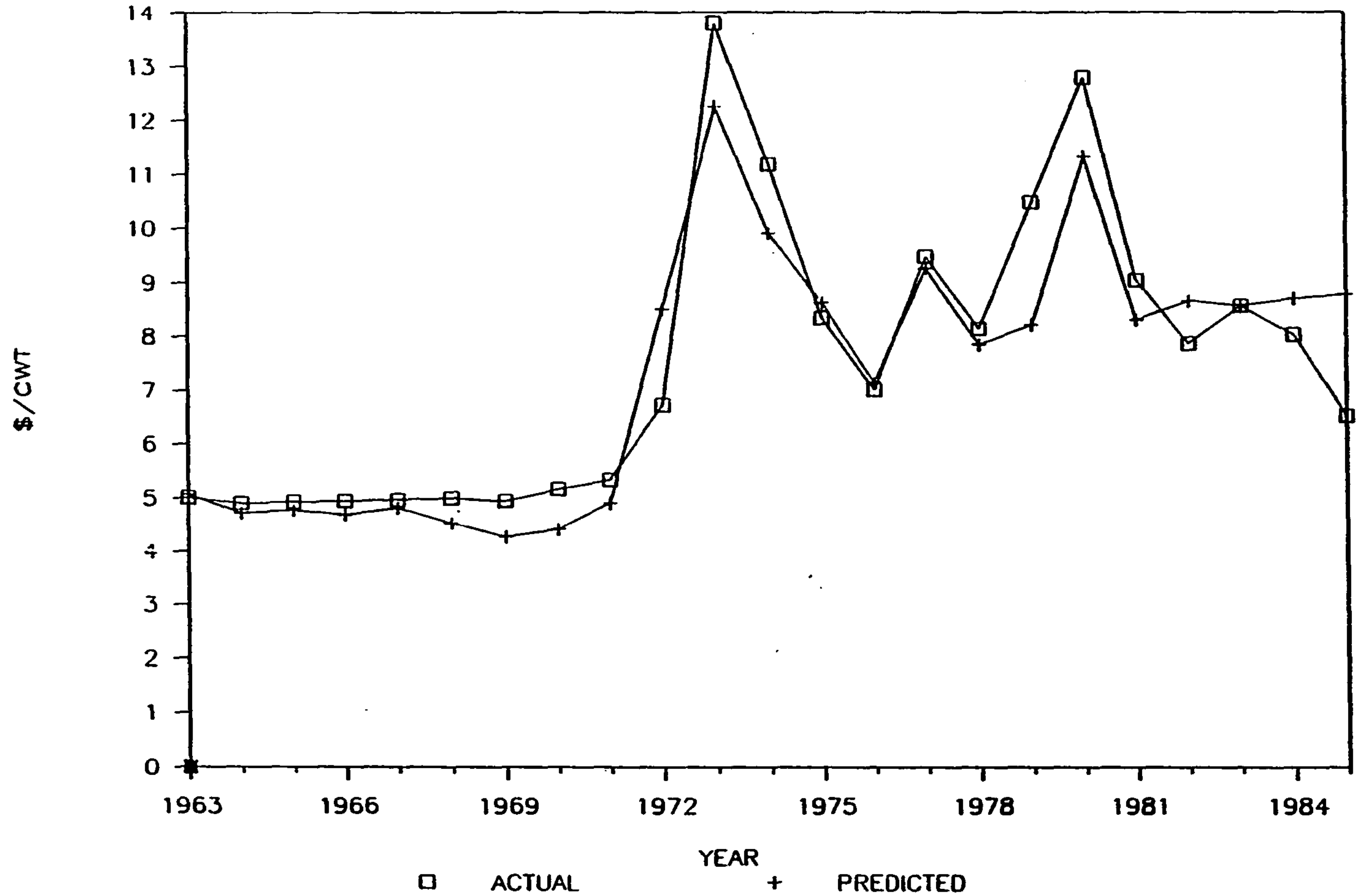

Figure 6.8: Predicted versus actual values of farm price

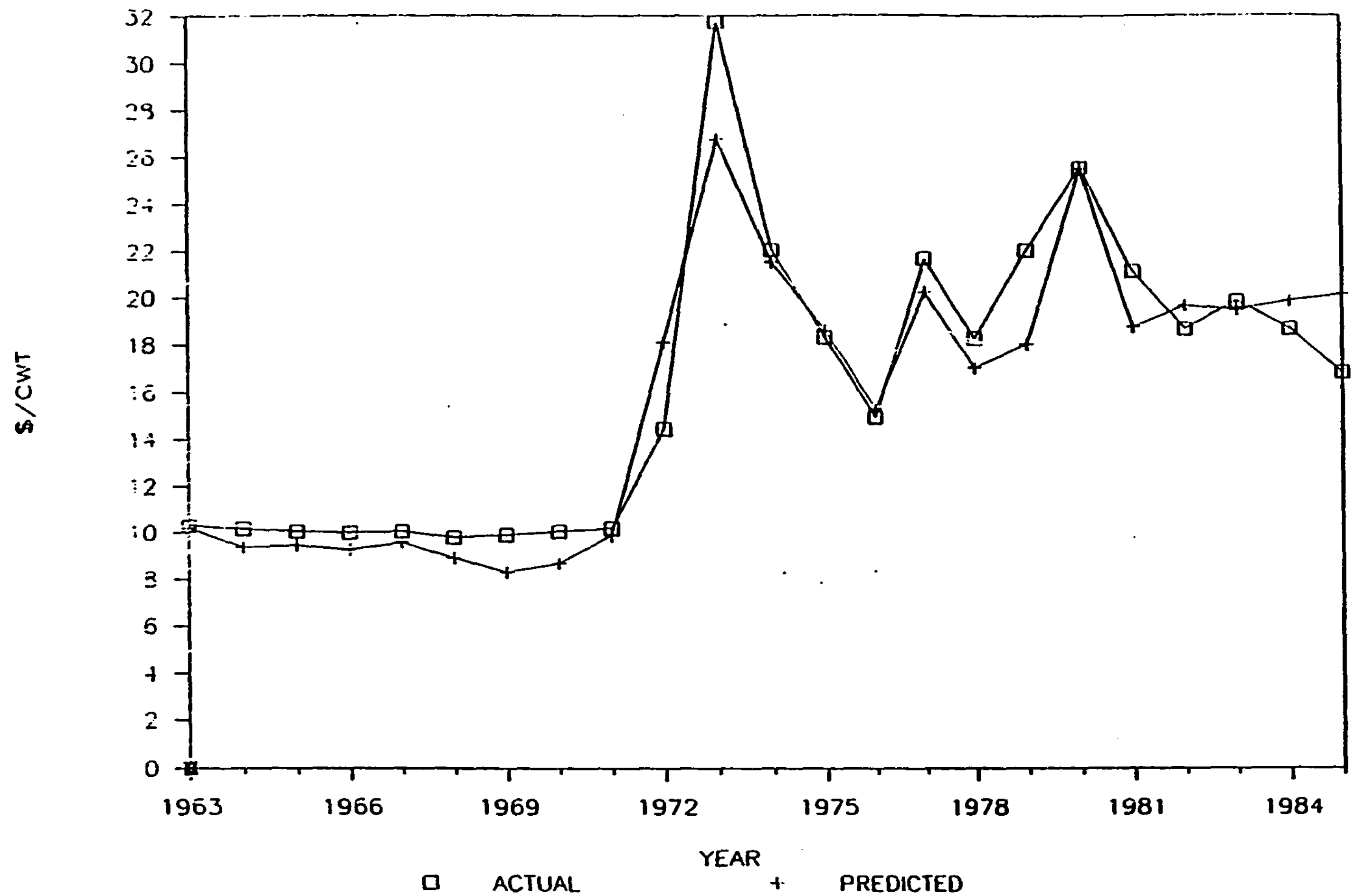

Figure 6.9: Predicted versus actual values of wholesale price

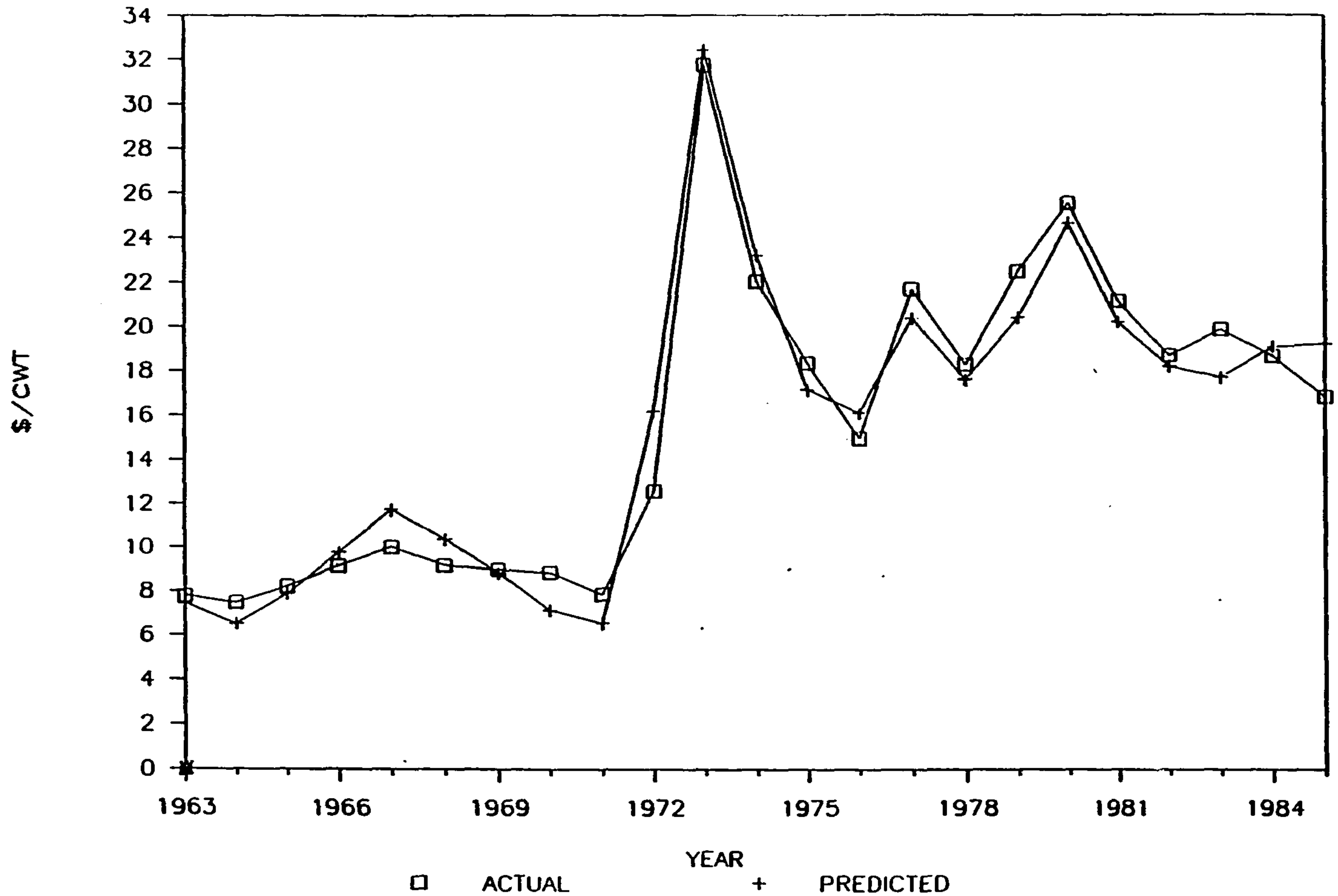

Figure 6.10: Predicted versus actual values of U.S. export price

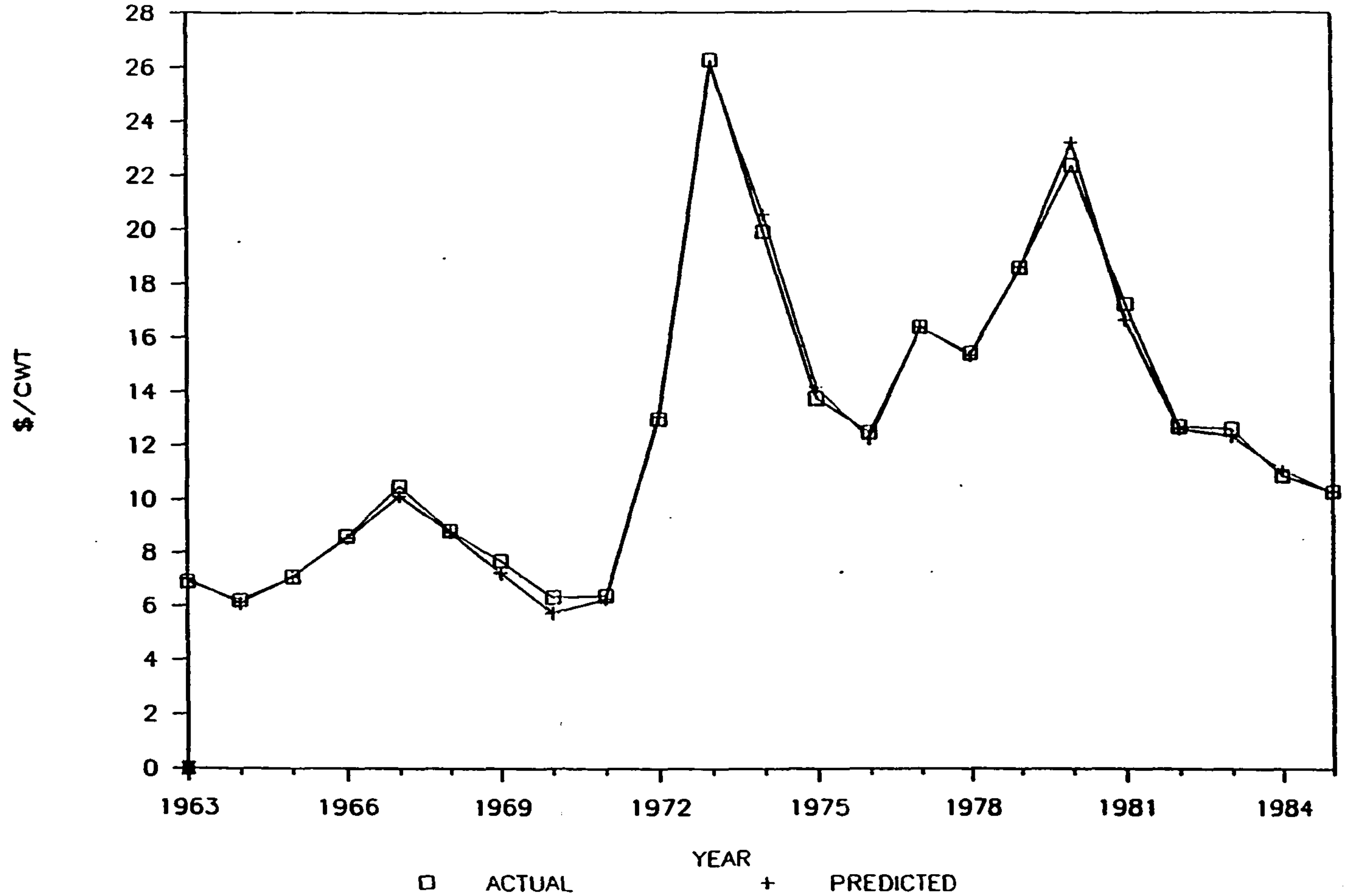

Figure 6.11: Predicted versus actual values of Thailand export price

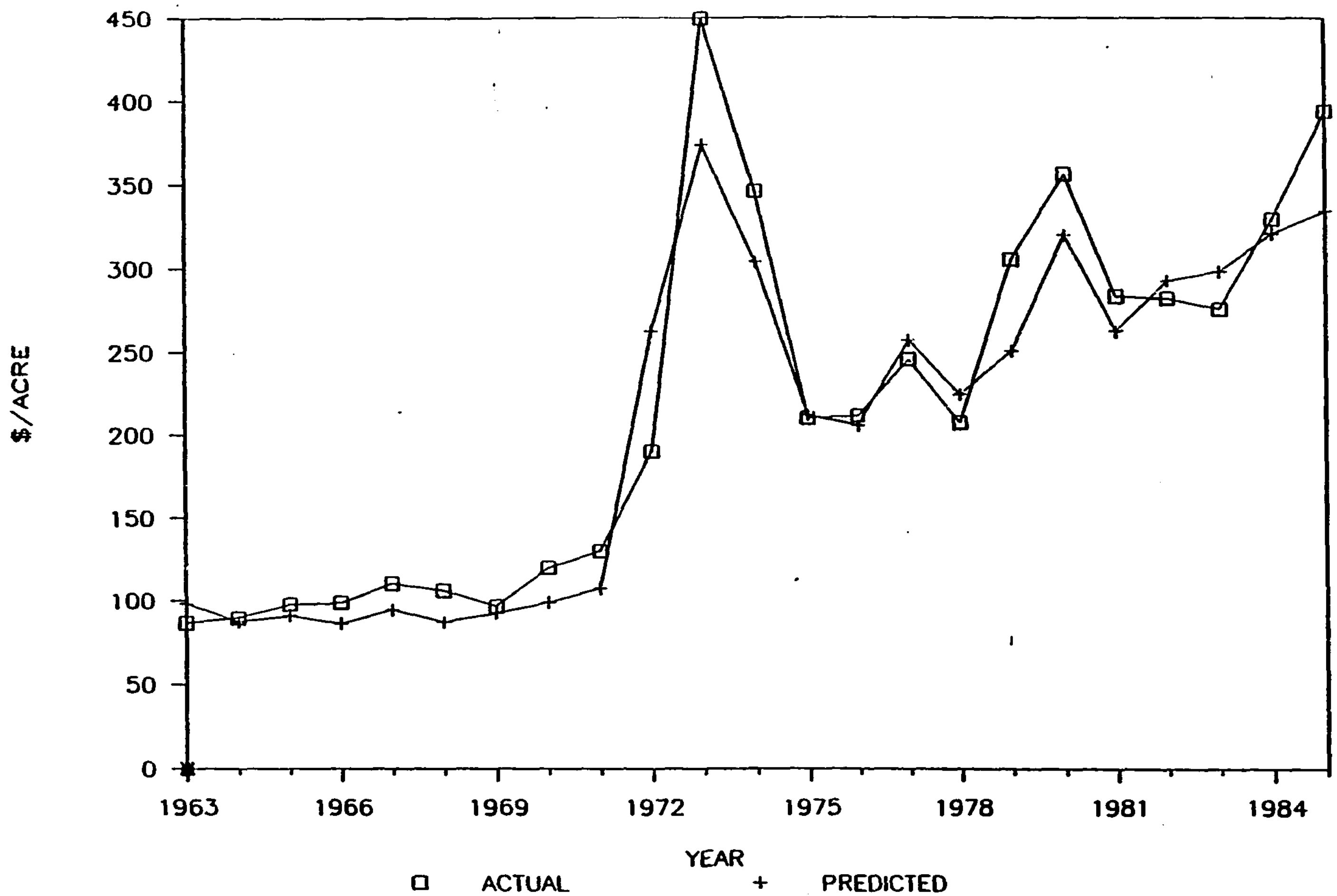

Figure 6.12: Predicted versus actual values of expected net returns

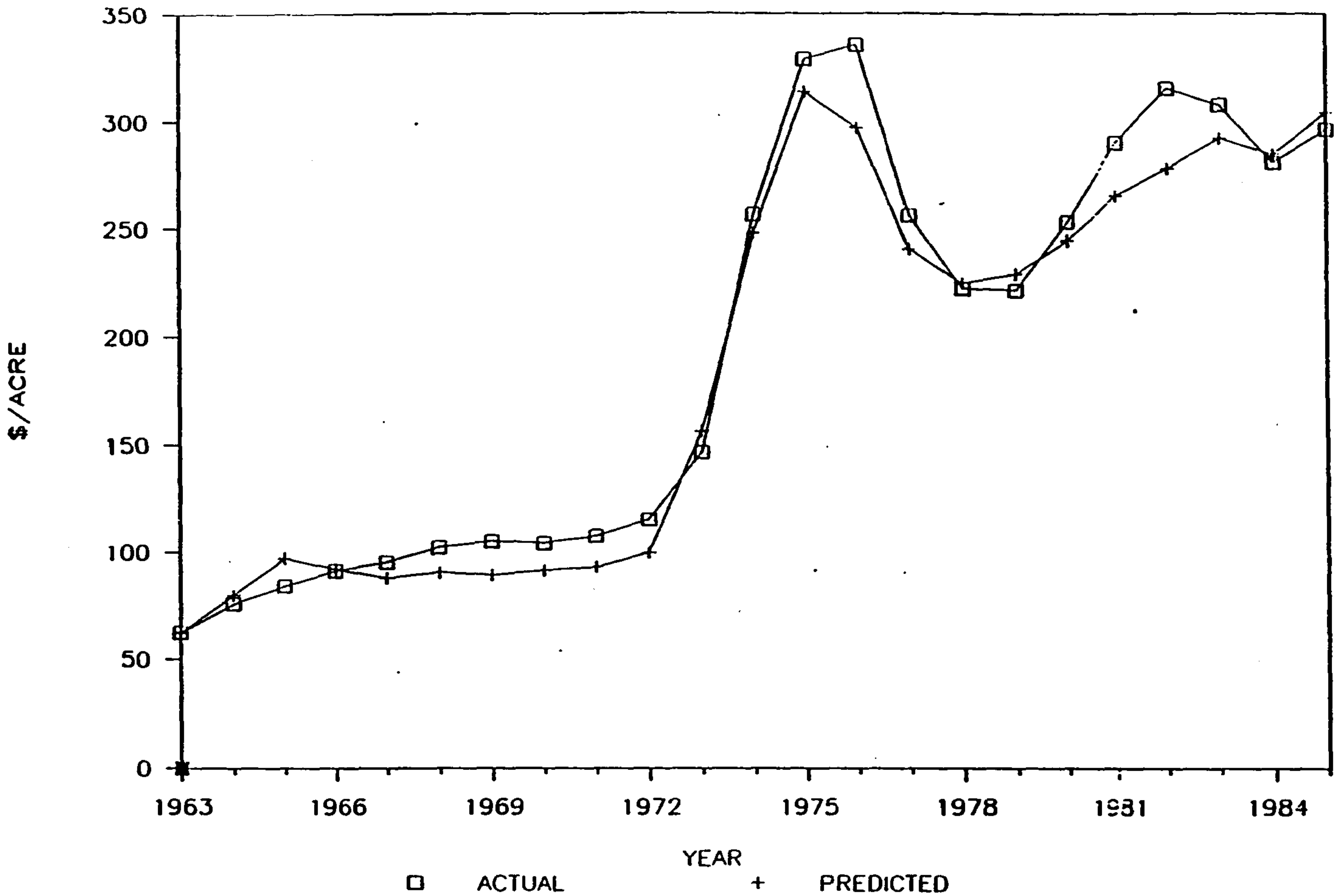

Figure 6.13: Predicted versus actual values of expected gross returns

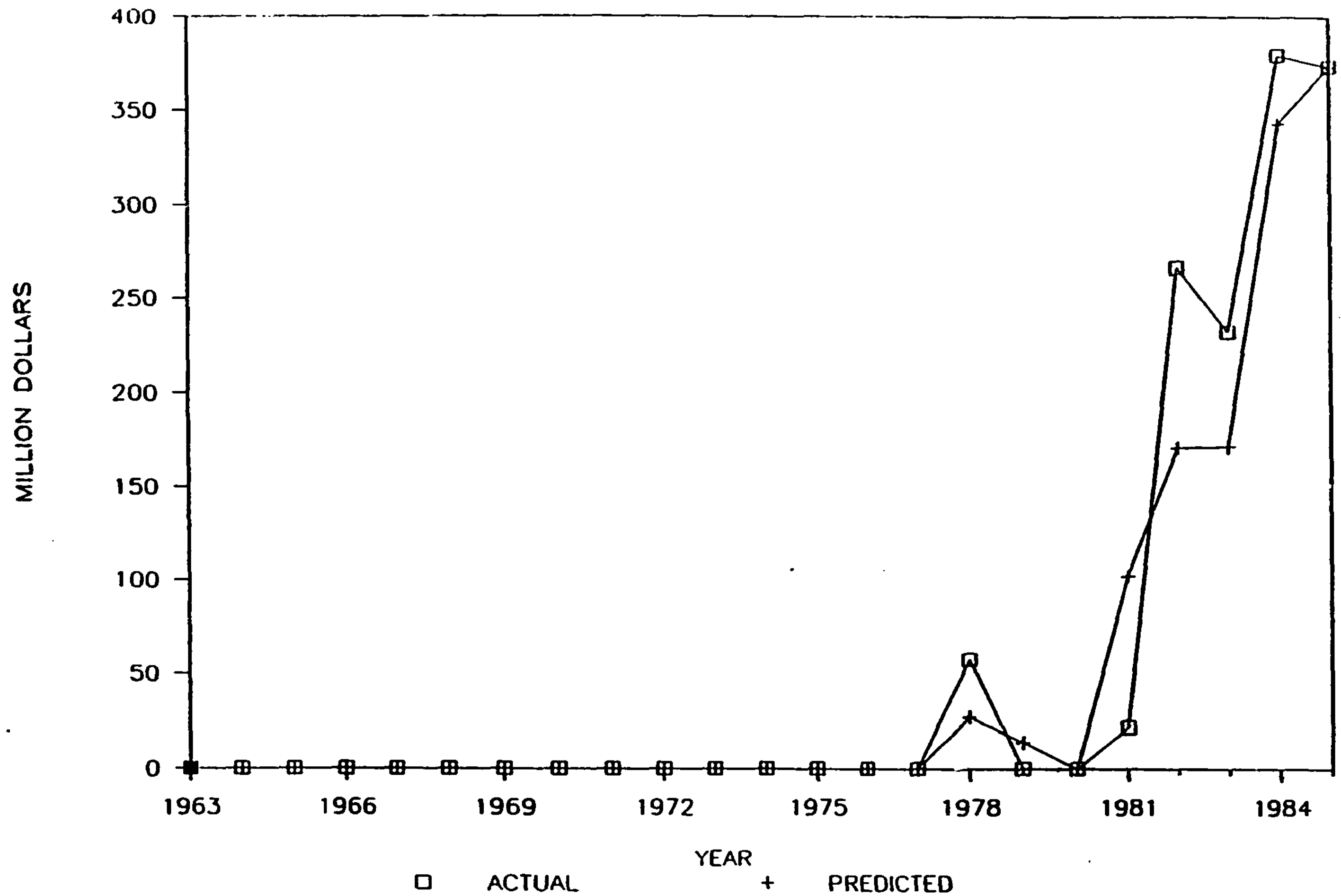

Figure 6.14: Predicted versus actual values of U.S. Government deficiency payments

The year 1973 was chosen because that was the year Thailand Government imposed big export tax. It came from the sharp increase in world rice price in 1973. Thus, we would expect the changes in the export tax of Thailand to have effect on the endogenous variables through the Thailand export price equation. Given this shock, the simulation is rerun over the period of 1973 to 1985. Table 6.3 reports the base simulated values and the changes in the values of the endogenous variables from the base solution due to the Thailand export tax decrease in 1973. The percentage change of all variables decreases as time passes, and all simulated results eventually approach the base solution.

As discussed in the theoretical formulation, the immediate effect of the Thailand export tax decrease will be on the Thailand export price. Thailand export price plays the key role on the U.S. export price and so also on U.S. commercial exports. The percentage change of Thailand price steadily declines from -8.28 percent to 0 percent from 1973 to 1985. The U.S. export price change also declines by -6.04 percent in 1973 and steadily decreases to zero in 1985.

The effect of the decrease in the Thailand export tax on the U.S. rice industry is transmitted through Thailand export price. A detailed analysis of the changes in the U.S. rice industry due to different exogenous shocks, including Thailand export tax scenario, will be discussed in the next chapter. However, the important point to note at present is that the fluctuation response of the endogenous variables to the exogenous shock declines from 1973 to 1985. Since most of the variables move back to their equilibrium values after the decrease in the Thailand export tax, the model is stable.

In summary, the results suggest that the model does an excellent job of depicting the behavior of endogenous variables. The model appears to provide a good foundation upon which to base further empirical research. In the next chapter, dynamic properties of the system will be more closely investigated through simulation analysis. Several interesting policy questions will be evaluated empirically.

7 SIMULATION ANALYSIS OF POLICY ALTERNATIVES AND FOREIGN DEMAND FLUCTUATIONS

This chapter analyzes the impacts of world import demand and policy changes of the two biggest rice exporting countries, i.e., U.S. and Thailand, on the U.S. rice industry. Hypothetical changes in economic and policy factors of interest were adopted, individually, to perform dynamic simulations using the estimated model described in Chapter 5. The comparison of the dynamic simulation results with and without a given event or policy shows the impact of such an event or policy. Three scenarios are examined. First, a Thailand export policy of sustained decrease in the export tax by ten percent from 1973 to 1985 and, secondly, a sustained increase in total production of major rice importing countries (i.e., which implies a decrease in the U.S. and Thailand export demands) by ten percent from 1973 to 1985, are investigated. Finally, the U.S. farm policy of a sustained decrease in the target price by ten percent from 1977 to 1985 is also investigated.

As discussed in Chapter 3, these policy and event variables are selected because they play very important roles on determining supply-demand and prices in the U.S. rice industry.

7.1 Analysis of Thailand Export Tax Decrease

Table 7.1 reports the simulation results of the Thailand export tax decrease for all endogenous variables. Since the export tax rate is altered every year from 1973 to 1985 by the Thailand Government, simulation result will have compounding effects on the endogenous variables. That is, the consequent changes in the endogenous variables in any period will include the dynamic effects of the decrease in Thailand export taxes of all previous periods.

As explained in previous chapters, reducing Thailand export taxes sets lower export prices of Thailand. Then not only does Thailand occupy some portion of U.S. export shares, but also U.S. has to bear lower export prices. In the simulation, the decreased Thailand export price ranged from a low of 5.60 percent in 1985 to a high of 8.71 percent in 1974. The decrease in Thailand export taxes has also a negative effect on U.S. export price. The percentage change in the U.S. export price declined by -6.04 percent in 1973 to -3.59 percent in 1985. On average a ten percent decrease in Thailand export taxes influenced Thailand export price by about 8 percent and U.S. export price by 5.5 percent. Therefore, U.S. commercial exports were affected negatively because the decreasing rate of Thailand export price was bigger than that of U.S. export price. The percentage change in the commercial exports ranged from a low of -1.82 in 1982 to a high of -10.05 in 1985. However, domestic food consumption and private stocks have positive effects, with decreasing rates, by the decrease in the Thailand export tax. Thus, there is a demand redistribution in the U.S. rice market, i.e., increase in domestic food consumption and private stocks, and decrease in commercial.

Turning to the supply side, the percentage changes in the planted acreage, harvested acreage, yields, and total production are relatively small or zero (see Table 7.1). The percentage changes in those variables are mostly less than one. The supply side is affected by Thailand export tax policy, indirectly, through U.S. farm price, while the demand side is directly affected through U.S. and Thailand export prices. Therefore, the impact of Thailand export policy on the supply side is smaller than that on the demand side. Moreover, even though U.S. farm price has relatively high negative effects by a -4.2 percent on average, the percentage changes in supply is low, because target price sets the price floor when U.S. farm price turns down below the target price.

The percentage changes in expected gross returns for rice producers ranged from a low of -0.34 in 1985 to a high of -7.70 in 1978. That is because both prices and supply decrease. Even though U.S. Government deficiency payments increase in some years, negative effects from low prices and supply dominates the deficiency payments effect and, hence, farmers' expected returns have negative effects. The percentage changes in U.S. Government deficiency payments ranged from a low of 5.60 in 1981 to a high of 189.55 in 1979 except some zero effects.

The impact of this Thailand export tax policy on farm (or wholesale) price, equilibrium quantities of rice supply, food demand, stocks, and exports, are exactly matched with the hypothesis in Chapter 3. The impacts are traced in Figure 3.2. Figure 3.1 represents that U.S. export demand shifts down because Thailand occupies some portion of U.S. export share by cutting their export tax. This result corresponds to a leftward shift of the market demand curve from D_0 to D_1 and a decrease of farm prices from P_0 to P_1. The decrease of the market price induces the incentives of domestic consumers to consume and of stock-holders to have more stocks. And the decrease of prices reduces the incentive of farmers to plant. Therefore, the new equilibrium is at E_1, which is the result of cutting Thailand export taxes in and prior to a selected year.

The long-run elasticities of endogenous variables, with respect to Thailand export tax decreases, are reported in Table 7.2. The long-run elasticities of rice supply associated with a 1-percent decrease in the Thailand export tax are inelastic, i.e., less than 0.1-percent. The long-run elasticities of rice demand, particularly domestic food consumption and commercial exports (0.34 and -0.37 respectively), are relatively more elastic than those of supply. At 0.12, the elasticity of private stocks with respect to Thailand export tax decrease is less elastic than those of other demand variables.

The elasticities of U.S. and Thailand export prices associated with a 1-percent decrease in the Thailand export tax are -0.56, -0.77 respectively, which are relatively more elastic than those of any other variables, except U.S. Government deficiency payments. These more elastic responses are as anticipated because both prices are directly affected by Thailand export tax policy. The long-run elasticities of both farm price and wholesale price are -0.42. Another interesting result is the value of 1.28 for long-run elasticity of U.S. Government deficiency payments, which implies that changes in Thailand export policies have significant effects on the U.S. rice commodity program.

In reviewing the results of this simulation analysis, several observations are suggested. First, the Thailand export tax has significant effects on U.S. export price, through Thailand export price. Downward pressure on the U.S. export price affects the competitive position of U.S. rice exports in the international market.

However, U.S. exports decrease, because quantity of the U.S. exports are dependent on the Thailand export price as well as the U.S. export price, and the decreasing rate of Thailand export price is bigger than that of U.S. export price.

Second, as the result of decreasing U.S. exports, the Thailand export tax policy performs the redistribution of domestic demand, i.e., domestic food consumption and private stocks holding, in the U.S. rice market. Lowering domestic prices make domestic demand increase. Furthermore, low domestic prices induce the incentives of farmers to plant less.

Finally, reducing the Thailand export tax causes expected returns for rice farmers to decline, and U.S. Government deficiency payments to rise. This foreign policy induces the U.S. Government to have more burden, because, given a fixed target price, the decreasing farm price causes more participants in the U.S. rice program. Therefore, Thailand export tax policy has significant effects on the U.S. rice economy.

Table 7.1: Dynamic impacts of a decrease in the Thailand export tax by ten percent from 1973 to 1985

Variable	Year	1973	1974	1975	1976	1977
Acreage planted	Base	2131.4	2521.1	2783.0	2848.0	2209.4
(1000 acres)	Change	0.87	-8.65	-18.22	-26.06	-22.33
	% change	0.04	-0.34	-0.65	-0.92	-1.01
Acreage harvested	Base	2136.9	2521.5	2779.9	2844.1	2213.9
(1000 acres)	Change	6.45	-8.11	-21.01	-29.61	-17.48
	% change	0.30	-0.32	-0.76	-1.04	-0.79
Yields per acre	Base	4223.6	4560.1	4499.9	4572.4	4624.8
(lbs/acre)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
Total production	Base	90267	114974	125090	130052	102389
(1000 cwt.)	Change	36.4	-389.4	-809.2	-1175.8	-1019.0
	% change	0.04	-0.34	-0.65	-0.90	-1.00
Domestic food consumption (1000 cwt.)	Base	10577.2	25144.1	26511.1	39154.8	31517.6
	Change	2030.2	1583.6	1512.7	884.1	1377.8
	% change	19.19	6.30	5.71	2.26	4.37
Commercial exports	Base	53227.1	47996.2	33394.7	52794.0	53060.6
(1000 cwt.)	Change	-1875.7	-1899.1	-2696.5	-1616.8	-2342.3
	% change	-3.52	-3.96	-8.08	-3.06	-4.41
Private stocks	Base	3575.8	9406.5	20861.6	23748.0	19032.3
(1000 cwt.)	Change	378.29	289.4	254.4	121.3	250.4
	% change	10.58	3.08	1.22	0.51	1.32
Farm price	Base	12.35	9.60	9.76	6.54	9.07
(dollars/cwt.)	Change	-0.46	-0.40	-0.41	-0.25	-0.41
	% change	-3.72	-4.12	-4.19	-3.82	-4.53
Wholesale price	Base	26.71	20.67	21.16	13.98	19.76
(dollars/cwt.)	Change	-1.04	-0.89	-0.92	-0.56	-0.93
	% change	-3.88	-4.31	-4.36	-4.03	-4.68

1978	1979	1980	1981	1982	1983	1984	1985
2776.6	2855.2	2857.5	3855.7	2991.7	2186.7	3085.5	2199.4
-22.77	-20.94	-15.80	-18.18	-18.51	-18.21	-6.69	-1.44
-0.82	-0.73	-0.55	-0.47	-0.62	-0.83	-0.22	-0.07
2773.6	2851.2	2853.5	3838.5	2985.9	2191.6	3078.4	2204.1
-25.42	-24.65	-19.60	-35.15	-24.05	-13.11	-13.63	3.26
-0.92	-0.86	-0.69	-0.91	-0.80	-0.60	-0.44	0.15
4669.2	4713.5	4641.3	4601.3	4764.3	4728.9	4773.7	5384.2
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
129501	134392	132433	176628	142266	103562	147828	118765
-1049.2	-973.9	-723.4	-825.6	-870.0	-849.5	-314.9	-76.5
-0.81	-0.72	-0.55	-0.47	-0.61	-0.82	-0.21	-0.06
33416.2	35363.2	30802.0	40313.7	39235.1	39208.9	41904.1	44103.9
977.1	910.3	1326.1	932.6	920.6	791.5	929.1	578.4
2.92	2.57	4.31	2.31	2.34	2.01	2.22	1.31
65660.4	74369.8	79074.2	85089.9	54738.9	41220.7	28964.2	27406.8
-1929.5	-1898.4	-1757.3	-1546.1	-1799.5	-2376.8	-1346.4	-2755.6
-2.94	-2.55	-2.22	-1.82	-3.29	-5.77	-4.65	-10.05
21967.5	22913.7	21065.6	28964.7	41001.1	21636.9	27009.9	24962.5
153.5	167.7	459.6	247.5	256.4	216.0	371.8	210.1
0.70	0.73	2.18	0.85	0.63	1.00	1.38	0.84
8.94	8.88	11.36	8.08	8.97	9.23	8.34	7.45
-0.31	-0.32	-0.52	-0.40	-0.41	-0.36	-0.44	-0.28
-3.47	-3.59	-4.58	-4.94	-4.62	-3.94	-5.31	-3.70
19.53	19.60	25.51	18.39	20.56	21.16	19.25	17.33
-0.70	-0.72	-1.17	-0.90	-0.94	-0.82	-1.00	-0.62
-3.58	-3.66	-4.59	-4.89	-4.55	-3.87	-5.18	-3.58

Table 7.1 (Continued)

Variable	Year	1973	1974	1975	1976	1977
U.S. export price	Base	28.96	22.76	19.31	15.38	19.90
(dollars/cwt.)	Change	-1.75	-1.47	-1.15	-0.84	-1.22
	% change	-6.04	-6.45	-5.97	-5.47	-6.13
Thailand export	BASE	26.43	20.81	14.02	13.44	15.48
price (dollars/cwt.)	Change	-2.19	-1.81	-1.19	-0.99	-1.32
	% change	-8.28	-8.71	-8.52	-7.34	-8.51
Expected net	Base	381.5	287.9	261.4	126.1	246.6
returns	Change	-19.42	-18.05	-18.41	-11.42	-19.00
(dollars/acre)	% change	-5.09	-6.27	-7.05	-9.05	-7.70
Expected gross	Base	153.8	245.1	300.4	310.3	225.1
returns	Change	0.62	-6.19	-13.03	-18.63	-15.96
(dollars/acre)	% change	0.41	-2.52	-4.34	-6.00	-7.09
Government deficiency	Base	0.00	0.00	0.00	0.00	0.00
payments	Change	0.00	0.00	0.00	0.00	0.00
(million dollars)	% change	0.00	0.00	0.00	0.00	0.00

1978	1979	1980	1981	1982	1983	1984	1985
19.35	20.37	25.31	19.29	19.43	19.22	18.81	17.57
-1.05	-1.20	-1.61	-1.17	-0.96	-0.86	-0.88	-0.63
-5.44	-5.91	-6.35	-6.08	-4.92	-4.48	-4.67	-3.59
16.33	18.39	21.49	16.14	12.60	11.79	10.65	9.52
-1.24	-1.50	-1.78	-1.26	-0.82	-0.76	-0.61	-0.53
-7.59	-8.16	-8.30	-7.79	-6.48	-6.42	-5.69	-5.60
242.3	249.4	319.2	260.1	286.1	294.6	320.1	347.6
-14.48	-0.39	-24.12	-15.17	0.25	0.58	-3.92	-14.84
-5.98	-0.16	-7.56	-5.83	0.09	0.20	-1.23	-4.27
211.4	205.0	246.1	270.3	276.2	288.5	280.2	300.3
-16.28	-14.97	-11.29	-13.00	-13.23	-13.01	-4.78	-1.03
-7.70	-7.30	-4.59	-4.81	-4.79	-4.51	-1.71	-0.34
27.44	13.90	0.00	102.18	171.26	171.89	343.46	374.00
0.00	26.34	0.00	5.73	47.63	33.67	41.35	0.00
0.00	189.55	0.00	5.60	27.81	19.59	12.04	0.00

Table 7.2: Dynamic elasticities of a sustained decrease in the Thailand export tax by ten percent

Variable	Long-run elasticity[a]
Acreage planted (1000 acres)	-0.06
Acreage harvested (1000 acres)	-0.06
Yields per acre (lbs)	0
Total production (1000 cwt.)	-0.05
Domestic food consumption (1000 cwt.)	0.34
Commercial exports (1000 cwt)	-0.37
Private stocks (1000 cwt)	0.12
Farm price ($/cwt.)	-0.42
Wholesale price ($/cwt.)	-0.42
U.S. export price ($/cwt.)	-0.56
Thailand export price ($/cwt.)	-0.77
Expected net returns ($/acre)	-0.44
Expected gross returns ($/acre)	-0.42
Government deficiency payments (million dollars)	1.28

[a]Calculated as average changes of endogenous variables divided by average changes of the Thailand export tax, and evaluated at the mean over the period 1973-1985.

7.2 Analysis of Foreign Demand Decrease

The second policy scenario examines the effect of expansionary total production of major importing countries. Increased total production of importers implies decreased export demand of major exporters. The dynamic simulation results of a increase in total production of major importing countries by 10-percent from 1973 to 1985 are reported in Table 7.3.

As explained in Chapter 3, shifting down the export demand facing duopolist, i.e., Thailand and U.S., causes export price and quantity of exports to fall. In turn decreased U.S. export price causes domestic prices (i.e., farm price and wholesale price) to fall. As a result, domestic food consumption and stocks rise. But U.S. acreage planted and total production fall. Expected returns for rice farmers have a negative effect because of lower farm price and lower export demand. Thus the U.S. Government has a burden to release more deficiency payments for rice farmers.

In the simulation, this foreign demand decrease scenario has exactly the same effect as the Thailand export tax scenario had. However, the magnitude of the impacts of this scenario are much smaller, i.e., less percentage changes. The percentage changes in the U.S. export price and Thailand export price, by a ten percent increase in the total production of major importers, are a high of -1.73 percent in 1984 and -2.08 percent in 1985, respectively. The percentage changes in most of the variables are less than 0.1 percent except Government deficiency payments with a 0.41 percent change. Like the results from the Thailand export tax policy, the impact of foreign demand decreases on supply side is much smaller than that on demand side.

Table 7.3: Dynamic impacts of a sustained increase in the total production of major importers by ten percent from 1973 to 1985

Variable	Year	1973	1974	1975	1976	1977
Acreage planted	Base	2131.4	2521.1	2783.0	2848.0	2209.4
(1000 acres)	Change	0.87	-o.34	-2.43	-3.29	-3.99
	% change	0.04	-0.01	-0.09	-0.12	-0.18
Acreage harvested	Base	2136.9	2521.5	2779.9	2844.1	2213.9
(1000 acres)	Change	6.45	0.10	-5.43	-7.13	0.62
	% change	0.30	0.00	-0.19	-0.25	0.03
Yields per acre	Base	4223.6	4560.1	4499.9	4572.4	4624.8
(lbs/acre)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
Total production	Base	90267	114974	125090	130052	102389
(1000 cwt.)	Change	36.41	-15.4	-107.8	-148.4	-181.9
	% change	0.04	-0.01	-0.09	-0.11	-0.18
Domestic food	Base	10577.2	25144.1	26511.1	39154.8	31517.6
consumption	Change	167.4	175.2	283.7	239.7	337.0
(1000 cwt.)	% change	1.58	0.70	1.07	0.61	1.07
Commercial exports	Base	53227.1	47996.2	33394.7	52794.0	53060.6
(1000 cwt.)	Change	-134.8	-200.3	-413.3	-291.3	-259.7
	% change	-0.25	-0.42	-1.24	-0.55	-0.49
Private stocks	Base	3575.8	9406.5	20861.6	23748.0	19032.3
(1000 cwt.)	Change	33.0	36.2	50.3	72.5	72.8
	% change	0.92	0.38	0.24	0.31	0.38
Farm price	Base	12.35	9.60	9.76	6.54	9.07
(dollars/cwt.)	Change	-0.04	-0.04	-0.08	-0.07	-0.10
	% change	-0.31	-0.46	-0.79	-1.04	-1.11
Wholesale price	Base	26.71	20.67	21.16	13.98	19.76
(dollars/cwt.)	Change	-0.09	-0.10	-0.17	-0.15	-0.23
	% change	-0.32	-0.48	-0.82	-1.09	-1.15

1978	1979	1980	1981	1982	1983	1984	1985
2776.6	2855.2	2857.5	3855.7	2991.7	2186.7	3085.5	2199.4
-5.52	-4.76	-3.33	-4.40	-3.98	-3.93	-0.63	0.27
-0.19	-0.17	-0.12	-0.11	-0.13	-0.18	-0.02	0.01
2773.6	2851.2	2853.5	3838.5	2985.9	2191.6	3078.4	2204.1
-8.10	-8.68	-7.30	-21.56	-9.72	0.98	-7.65	4.96
-0.29	-0.30	-0.26	-0.56	-0.32	0.04	-0.25	0.23
4669.2	4713.5	4641.3	4601.3	4764.3	4728.9	4773.7	5384.2
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
129501	134392	132433	176628	142266	103562	147828	118765
-240.6	-221.2	-152.5	-199.9	-187.1	-183.4	-29.6	14.6
-0.19	-0.16	-0.12	-0.11	-0.13	-0.18	-0.02	0.01
33416.2	35363.2	30802.0	40313.7	39235.1	39208.9	41904.1	44103.9
165.6	96.6	382.0	240.2	244.0	178.8	362.0	96.7
0.50	0.27	1.24	0.60	0.62	0.46	0.86	0.22
65660.4	74369.8	79074.2	85089.9	54738.9	41220.7	28964.2	27406.8
-353.4	-304.3	212.0	-47.7	-429.5	-727.6	-243.0	-1517.5
-0.54	-0.41	0.27	-0.06	-0.78	-1.77	-0.84	-5.54
21967.5	22913.7	21065.6	28964.7	41001.1	21636.9	27009.9	24962.5
20.0	6.5	208.7	73.7	72.1	47.5	178.8	31.0
0.09	0.03	0.99	0.25	0.18	0.22	0.66	0.12
8.94	8.88	11.36	8.08	8.97	9.23	8.34	7.45
-0.05	-0.03	-0.15	-0.10	-0.11	-0.08	-0.17	-0.05
-0.59	-0.38	-1.32	-1.27	-1.23	-0.89	-2.07	-0.62
19.53	19.60	25.51	18.39	20.56	21.16	19.25	17.33
-0.12	-0.08	-0.34	-0.23	-0.25	-0.19	-0.39	-0.10
-0.61	-0.39	-1.32	-1.26	-1.21	-0.88	-2.02	-0.60

Table 7.3 (Continued)

Variable	Year	1973	1974	1975	1976	1977
U.S. export price	Base	28.96	22.76	19.31	15.38	19.90
(dollars/cwt.)	Change	-0.14	-0.16	-0.21	-0.21	-0.26
	% change	-0.49	-0.72	-1.08	-1.35	-1.29
Thailand export	BASE	26.43	20.81	14.02	13.44	15.48
price (dollars/cwt.)	Change	-0.18	-0.20	-0.21	-0.23	-0.24
	% change	-0.66	-0.98	-1.50	-1.71	-1.57
Expected net	Base	381.5	287.9	261.4	126.1	246.6
returns	Change	-1.60	-2.00	-3.45	-3.10	-4.65
(dollars/acre)	% change	-0.42	-0.69	-1.32	-2.46	-1.88
Expected gross	Base	153.8	245.1	300.4	310.3	225.1
returns	Change	0.62	-0.24	-1.74	-2.35	-2.85
(dollars/acre)	% change	0.41	-0.10	-0.58	-0.76	-1.27
Government deficiency	Base	0.00	0.00	0.00	0.00	0.00
payments	Change	0.00	0.00	0.00	0.00	0.00
(million dollars)	% change	0.00	0.00	0.00	0.00	0.00

1978	1979	1980	1981	1982	1983	1984	1985
19.35	20.37	25.31	19.29	19.43	19.22	18.81	17.57
-0.19	-0.16	-0.29	-0.24	-0.25	-0.21	-0.32	-0.16
-0.97	-0.77	-1.14	-1.25	-1.29	-1.10	-1.73	-0.93
16.33	18.39	21.49	16.14	12.60	11.79	10.65	9.52
-0.23	-0.21	-0.19	-0.21	-0.21	-0.20	-0.20	-0.20
-1.39	-1.16	-0.89	-1.31	-1.68	-1.73	-1.92	-2.08
242.3	249.4	319.2	260.1	286.1	294.6	320.1	347.6
-2.45	-0.04	-6.95	-1.54	0.07	0.13	0.39	-2.48
-1.01	-0.02	-2.18	-0.59	0.02	0.04	0.12	-0.71
211.4	205.0	246.1	270.3	276.2	288.5	280.2	300.3
-3.73	-3.40	-2.38	-3.15	-2.84	-2.81	-0.45	0.20
-1.77	-1.66	-0.97	-1.16	-1.03	-0.97	-0.16	0.07
27.44	13.90	0.00	102.18	171.26	171.89	343.46	374.00
0.00	2.79	0.00	5.73	12.62	7.61	20.72	0.00
0.00	20.11	0.00	5.60	7.37	4.42	6.03	0.00

Table 7.4: Dynamic elasticities of a sustained increase in the total production of major importers by ten percent

Variable	Long-run elasticity[a]
Acreage planted (1000 acres)	-0.01
Acreage harvested (1000 acres)	-0.01
Yields per acre (lbs)	0
Total production (1000 cwt.)	-0.01
Domestic food consumption (1000 cwt.)	0.07
Commercial exports (1000 cwt)	-0.07
Private stocks (1000 cwt)	0.03
Farm price ($/cwt.)	-0.09
Wholesale price ($/cwt.)	-0.09
U.S. export price ($/cwt.)	-0.11
Thailand export price ($/cwt.)	-0.13
Expected net returns ($/acre)	-0.08
Expected gross returns ($/acre)	-0.08
Government deficiency payments (million dollars)	0.41

[a] Calculated as average changes of endogenous variables divided by average changes of the total production of major importers, and evaluated at the mean over the period 1973-1985.

The impact of foreign demand decreases on prices, equilibrium quantities of rice supply, domestic demand, stocks, and exports, can be analyzed with the help of Figure 3.3. Figure 3.3 represents that U.S. export demand shifts down because of decreased world demand. This result corresponds to a leftward shift of the market demand curve from D_0 to D_1 and a decrease of farm prices from P_0 to P_1 in the U.S. rice market. The decrease in market price induces the incentives of domestic consumers to consume and of stock-holders to have more stocks. And the decrease of prices reduces the incentives of farmers to plant. Therefore, the new equilibrium is at E_1, which is the result of foreign demand decreases in and prior to a selected year.

The long-run elasticities of endogenous variables, with respect to an increase in importers' total production, are reported in Table 7.4. The long-run elasticities of rice supply associated with a 1-percent increase in the total production of major importing countries are very inelastic, i.e., less than 0.01-percent. The long-run elasticities of rice demand, particularly domestic food consumption, commercial, and private stocks, are also very inelastic, i.e., less than 0.1-percent. The elasticities of U.S. and Thailand export prices associated with a 1-percent increase in the total production of major importers are -0.11 and -0.13 respectively, which are relatively more elastic than those of any others, except U.S. Government deficiency payments. Another interesting result is the value of 0.41 for the long-run elasticity of U.S. Government deficiency payments, which implies that world demand fluctuation have relatively significant effects on the U.S. rice program.

7.3 Analysis of U.S. Target Price Decrease

The simulation results of sustained decreases in the target price by ten percent from 1977 to 1985 are reported in Table 7.5. Since the inauguration of the target price program in 1976, the years from 1977 to 1985 were selected.

A ten percent decrease of the target price causes farmers to plant less, owing to a decrease in the expected gross returns, which leads total rice supply to be less. The percentage change in the acreage planted continues to rise from -0.08 percent in 1978 to -3.58 percent in 1985. Thus, the percentage change in the total production also continues to rise from -0.08 percent in 1978 to -3.52 percent in 1985. Given everything else unchanged, there is less rice available for domestic food consumption, exports, and carryover. The tight supply results in increases in the farm price. Lower rice supply also results in a higher wholesale price. Therefore, lower expected returns for rice farmers are expected, whereas the U.S. Government deficiency payments continue to fall from -100.00 percent in 1979 to -35.99 percent in 1985.

The impact of this contractionary target price policy on supply, demand, stocks, exports, and prices, can be analyzed with the help of Figure 3.5. A decrease of the target price causes a decrease in expected returns, which leads acreage planted less and hence lower rice supply. Therefore, the supply curve shifts from S_0 to S_1 in Figure 3.5. Since graphical analysis does not permit to analyze the dynamic changes in the endogenous variables over time, the year 1985 is chosen to examine the changes in the endogenous variables.

Table 7.5: Dynamic impacts of a sustained decrease in the target price by ten percent from 1977 to 1985

Variable	Year	1977	1978	1979	1980	1981
Acreage planted	Base	2209.4	2776.6	2855.2	2857.5	3855.7
(1000 acres)	Change	0.00	-2.15	-2.91	-6.67	-6.38
	% change	0.00	-0.08	-0.10	-0.23	-0.17
Acreage harvested	Base	2214.0	2773.6	2851.2	2853.5	3838.5
(1000 acres)	Change	4.55	-5.06	--6.85	-10.59	-23.51
	% change	0.21	-0.18	-0.24	-0.37	-0.61
Yields per acre	Base	4624.8	4669.2	4713.49	4641.3	4601.32
(lbs/acre)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
Total production	Base	102389	129501	134392	132433	176628
(1000 cwt.)	Change	0.00	-98.8	-135.2	-305.3	-289.9
	% change	0.00	-0.08	-0.10	-0.23	-0.16
Domestic food	Base	31517.6	33416.2	35363.2	30802.0	40313.7
consumption	Change	331.0	113.3	19.9	217.9	56.9
(1000 cwt.)	% change	1.05	0.34	0.06	0.71	0.14
Commercial exports	Base	53060.6	65660.4	74369.8	79074.2	85089.9
(1000 cwt.)	Change	556.7	192.3	33.0	346.8	131.6
	% change	1.05	0.29	0.04	0.44	0.16
Private stocks	Base	19032.3	21967.5	22913.7	21065.6	28964.7
(1000 cwt.)	Change	-598.6	-654.7	-758.1	-647.5	-888.2
	% change	-3.15	-2.98	-3.31	-3.07	-3.07
Farm price	Base	9.07	8.94	8.88	11.36	8.08
(dollars/cwt.)	Change	-0.10	-0.04	-0.01	-0.09	-0.02
	% change	-1.09	-0.40	-0.08	-0.08	-0.75
Wholesale price	Base	19.76	19.53	19.60	25.51	18.39
(dollars/cwt.)	Change	-0.22	-0.08	-0.02	-0.19	-0.05
	% change	-1.13	-0.42	-0.08	-0.75	-0.30

1982	1983	1984	1985
2991.7	2186.7	3085.5	2199.4
-28.46	-49.15	-73.48	-78.69
-0.95	-2.25	-2.38	-3.58
2985.9	2191.6	3078.4	2204.1
-33.87	-43.65	-79.54	-72.97
-1.13	-2.00	-2.58	-3.32
4764.3	4728.9	4773.7	5384.2
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
142266	103562	147828	118765
-1337.9	-2293.7	-3461.5	-4180.9
-0.94	-2.21	-2.34	-3.52
39235.1	39208.9	41904.1	44103.9
-266.1	-541.8	-632.1	-1011.9
-0.68	-1.38	-1.51	-2.29
54738.9	41220.7	28964.2	27406.8
-831.1	-1843.8	-2468.8	-4423.1
-1.52	-4.47	-8.52	-16.14
41001.1	21636.9	27009.9	24962.5
-1129.0	-1368.4	-1537.7	-1795.0
-2.75	-6.32	-5.69	-7.19
8.97	9.23	8.34	7.45
0.12	0.25	0.30	0.48
1.34	2.70	3.61	6.47
20.56	21.16	19.25	17.33
0.27	0.56	0.68	1.09
1.31	2.65	3.53	6.27

Table 7.5 (Continued)

Variable	Year	1977	1978	1979	1980	1981
U.S. export price	Base	19.90	19.35	20.37	25.31	19.29
(dollars/cwt.)	Change	-0.12	-0.04	-0.01	-0.11	-0.03
	% change	-0.62	-0.23	-0.04	-0.42	-0.16
Thailand export	BASE	15.48	16.33	18.39	21.49	16.14
price (dollars/cwt.)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
Expected net	Base	246.60	242.33	249.37	319.19	260.10
returns	Change	-4.57	-1.68	-8.05	-3.96	-49.01
(dollars/acre)	% change	-1.85	-0.69	-3.23	-1.24	-18.84
Expected gross	Base	225.15	211.36	205.02	246.10	270.29
returns	Change	0.00	-1.53	-2.08	-4.76	-4.56
(dollars/acre)	% change	0.00	-0.73	-1.01	-1.94	-1.69
Government deficiency	Base	0.00	27.44	13.90	0.00	102.18
payments	Change	0.00	0.00	-13.90	0.00	-86.21
(million dollars)	% change	0.00	0.00	-100.00	0.00	-84.37

1982	1983	1984	1985
19.43	19.22	18.81	17.57
0.15	0.31	0.76	0.60
0.77	1.61	2.00	3.42
12.60	11.79	10.65	9.52
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
286.1	294.6	320.1	347.6
-52.42	-56.13	-60.18	-33.96
-18.33	-19.06	-18.80	-9.77
276.2	288.5	280.2	300.3
-20.34	-35.13	-52.52	-56.25
-7.36	-12.18	-18.74	-18.73
171.26	171.89	343.46	374.00
-138.31	-128.55	-179.10	-134.60
-80.76	-74.79	-52.14	-35.99

Table 7.6: Dynamic elasticities of a sustained decrease in the U.S. target price by ten percent

Variable	Long-run elasticity[a]
Acreage planted (1000 acres)	-0.10
Acreage harvested (1000 acres)	-0.10
Yields per acre (lbs)	0.00
Total production (1000 cwt.)	-0.10
Domestic food consumption (1000 cwt.)	-0.05
Commercial exports (1000 cwt)	-0.16
Private stocks (1000 cwt)	-0.41
Farm price ($/cwt.)	0.11
Wholesale price ($/cwt.)	0.11
U.S. export price ($/cwt.)	0.06
Thailand export price ($/cwt.)	0.00[b]
Expected net returns ($/acre)	-1.05
Expected gross returns ($/acre)	-0.77
Government deficiency payments (million dollars)	-5.65

[a]Calculated as average changes of endogenous variables divided by average changes of the target price, and evaluated at the mean over the period 1977-1985.

[b]Target price has a positive effect on the Thailand export price, but the long-run elasticity is close to zero.

In the year 1985, the new equilibrium is at E_1, which is the result of a target price decrease in 1985 and also prior to 1985. At this equilibrium, the farm price rises to P_1, i.e., by 6.47 percent (refer to Table 7.5). This rise in the farm price is caused by the decrease in the supply schedule. The equilibrium quantities of domestic food consumption and stock inventories decline by -2.29 percent and -7.19 percent respectively, because of the higher price. The equilibrium quantity of commercial exports also declines by -16.14 percent, which implies that commercial exports are very sensitive to changes in domestic prices as well as U.S. export price. Given this decrease in the equilibrium quantities and increase in prices, we would anticipate the expected returns for rice farmers and U.S. Government deficiency payments to fall. Thus, it is clear that rice farmers are hurt by decreases in target price, through less deficiency payments.

The long-run elasticities of endogenous variables with respect to target price decreases are reported in Table 7.6. The long-run elasticities of acreage planted, acreage harvested, and total production associated with a 1-percent decrease in the target price are inelastic at -0.1. This inelastic response is anticipated because there is only one year (1978), before 1981, when target price was in effect in the rice market. Another important result is the long-run elasticities of the expected (net) returns for rice farmers and U.S. Government deficiency payments are -1.05 and -5.65, respectively, which implies that the changes in target price policies have significant effects on the rice farmers and U.S. Government expenditures for the rice program. Furthermore, from the above results, a decrease in the target price policy does not favor the rice producing farmers by decreasing their returns without any other support schemes.

8 SUMMARY AND CONCLUSIONS

Government intervention in the U.S. agricultural sector has a long history over the last five decades. This continues to be a cornerstone of U.S. farm policy. Government commodity programs have both direct and indirect effects on farmers, consumers, and taxpayers. Export-oriented policies of Thailand can also have dramatic consequences on supply, demand, and prices in the U.S. rice industry, and hence it has also indirect effects on farmers, consumers, and taxpayers in the U.S. rice economy. Furthermore, small swings in the stream of imports causes U.S. agricultural policies to reform because the U.S. rice industry heavily depends upon the world rice market, with more than 60 percent of national rice production as an outlet for exports. Thus a sudden world demand fluctuation will affect domestic and world price, equilibrium quantities of rice supply-demand, and in turn U.S. farmers' expected returns and U.S. Government expenditures.

Under a Stackelberg duopoly assumption, Thailand as a price-leader and U.S. as a price-follower, an economic supply-demand model that represents economic forces acting in the U.S. rice industry was formulated. The general concerns of this study are to examine the effects of alternative policies of U.S. and Thailand, and world demand fluctuations on U.S. rice economy by using this economic framework.

A general description of the U.S. rice economy and major relationships and variables involved in the U.S. rice economy were presented in Chapter 2. The theoretical model with U.S. and Thailand policy mechanisms in the world rice market was illustrated in Chapter 3. The structural framework for U.S. rice market was then developed, based upon prior information and economic theory, in the following chapter.

Since the model was nonlinear and simultaneous, nonlinear three-stage least squares from SAS/ETS was adopted to estimate the model in Chapter 5. The sample period of the study was 1960 - 1985 using annual data. The performance of the model was evaluated by its ability to reproduce the actual data in an ex-post simulation, the validity of its estimates, and its stability in Chapter 6. The estimated directional relationships among variables were consistent with a priori expectations, and the estimated coefficients had good statistical properties. The dynamic historical simulation over the entire study period to test the validity of the model proved satisfactory, and tracked the turning points of the endogenous variables very well. Moreover, in one period, the exogenous shock of a decrease in the Thailand export tax in 1972, showed the convergence of equilibrium values, indicating the model was stable.

To examine the effects of changes in economic and policy instruments of interest such as U.S. Government support price, export tax of Thailand Government, and world demand fluctuations on supply, demand, prices, U.S. Government program costs (i.e., deficiency payments), and the expected returns for rice farmers in the U.S. rice market, dynamic simulations were performed in Chapter 7.

Several conclusions, from the estimated results and the simulation experiments, can be summarized as follows:

First, all the estimated coefficients of the variables have the right signs and are statistically significant and, thus, this study has provided important information to analyze the U.S. rice market related to the world rice market, including the supply and demand conditions of the rice industry, price linkages between domestic and world markets, and the world demand situation and agricultural policies of U.S. and Thailand affecting the U.S. rice market.

Second, considering the significance of Thailand export policy to the U.S. rice market, this study endogenizes the Thailand export price using a Stackelberg duopoly model to world equilibrium price determination. All the explanatory variables in the export price equations of both U.S. and Thailand have the expected signs and are highly significant. Moreover, the U.S. export price elasticity with respect to Thailand export price is 0.75, which implies the U.S. export price is sensitive to change in Thailand export prices. Therefore, the results lend support to the Stackelberg duopoly approach, Thailand as a price-leader and U.S. as a price-follower.

Third, the simulation experiments suggest that the Thailand export tax has much more significant impacts on the U.S. rice market than the other two factors (i.e., World demand fluctuation and U.S. support price). Looking at the percentage changes in supply, demand, expected returns for farmers, and U.S. Government deficiency payments, the Thailand export tax has the largest impact upon the U.S. rice economy. Furthermore, U.S. target price has a little larger impact than world demand fluctuations. These imply direct government interventions bring more effective results.

Fourth, the effects of the world demand changes are captured in the Thailand export price. The lower world demand, caused by the higher total production of major importing countries, results in reduction of U.S. exports and expected returns to farmers, and, hence rice farmers produce less rice and join the government program more. Therefore, U.S. Government has to take more expenditures and to reform the agricultural policies.

Fifth, the effect of a lower target price policy suggests that such policy action has a negative impact on the rice farmers and consumers. A deduction in the level of the target price increases the farm price and export price, but decreases U.S. Government expenditure and returns to farmers. However, the magnitude of the effect on Government expenditure is extremely larger than any other negative effects on farmers and consumers.

Sixth, the supply elasticities to all of the policy shocks are relatively low. The most common approach used to incorporate the influence of commodity program is the inclusion of effective support payment and diversion payment variables as explanatory variables in the planted acres equations (De Gorter and Paddock, 1985; Skold and Westhoff, 1987). That is, acreage controls in the estimates of supply response are implicitly, not explicitly, included. Perhaps it is a reason for the relatively low elasticities of supply in this study.

Finally, expected returns for rice producers and U.S. Government deficiency payments, comparing to any other variables, are more sensitive for all policy scenarios mentioned above. The result can be explained by the fact that expected returns and U.S. Government deficiency payment variables absorb all price and quantity changes directly in the model.

In reality, when one allows market conditions to change, the effects of such policies depend upon how such market conditions interact upon each other. It also depends upon the perception of economic agents on the government policy. If economic agents perceive that such a policy is permanent, farmers' decisions to plant will reveal more of market conditions. It is also an incentive for them to improve the input mix in order to reduce cost of production, if they want to remain competitive. Simulation results indicate that an aggressive export policy of Thailand, an expansionary total production policy of major importers, and market-oriented policies of the U.S. Government, might seem to hurt the rice farmers because of the lower farm price and supply, and hence loss of expected returns to rice farmers. Therefore, as the level of government support drops, the incentive to participate in the government program will be lower.

Even though the results of this study were statistically satisfactory and all the objectives were accomplished, there are some areas which can be explored for further research. First, the Thailand export price equation was integrated into the U.S. rice model in this study, but it was not thoroughly explored. More specific characteristics of oligopolistic (or duopolistic) market could be incorporated in the model based on a further detailed study of the behaviors of large rice exporters and importers in the world. Addition of these markets would give a better picture to analyze the U.S. rice industry in the world market.

Second, since government exports are not endogenized, this study does not take into account the total government expenditure, and the impacts of policy alternatives is examined only on government deficiency payments, not on total expenditures. The rice exports can be roughly divided into the commercial trade and the bilateral or government-to-government trade which includes food aid. Since the methods of determining price and quantity in the two types of rice trade seem to be very different, the economic model should be improved so that it will explain these two types of rice exports simultaneously.

Third, because other food crops such as wheat and corn have great effects on the domestic rice market as well as on the world market, it is appropriate to expand the economic model so that it can handle not only the rice market but also markets in the other crops and the interrelations among these markets.

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